THE

ANATOMY AND PHYSIOLOGY

OF THE

HUMAN BODY.

BY

JOHN AND CHARLES BELL.

THE SEVENTH EDITION:

IN WHICH THE WHOLE IS MORE PERFECTLY SYSTEMATIZED AND CORRECTED

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THE

ANATOMY

OF THE

HUMAN BODY.

VOL. III.

CONTAINING

THE ANATOMY

OF

THE ORGANS OF THE SENSES,

THE VISCERA OF THE ABDOMEN,

AND

THE MALE AND FEMALE PARTS OF GENERATION.

CONTENTS

OF

THE THIRD VOLUME.

ANATOMY

OF THE

ORGANS OF THE SENSES.

OF THE SENSES.

OF THE EYE.

OF THE EAR.

OF THE NOSE, AND ORGAN OF SMELLING.

OF THE MOUTH, SALIVARY GLANDS, THE ORGAN OF TASTE, &c.

OF THE SKIN, AND SENSE OF TOUCH.

THE

ANATOMY

OF THE

VISCERA OF THE ABDOMEN.

INTRODUCTION.

ANATOMY

OF THE

VISCERA OF THE PELVIS.

TO THE BINDER.

The Six Plates for Vol. III. are to be placed at the End of the Volume.

EXPLANATION

OF

THE PLATES.

PLATE IV.

THIS plate represents the prostate gland, vesiculæ seminales, and lower part of the bladder, the parts being previously hardened in spirits, the vesiculæ were afterwards cut open.

A A. The body of the PROSTATE GLAND; it is that lower part of the gland which can be felt through the rectum.

B. The prostate gland is here cut into and dissected, in following the ducts of the vesiculæ.

C. The extremities of the ducts common to the vesiculæ seminales and vasa deferentia.

D D. The cells of the vesiculæ seminales, which are laid open by a section.

E. The left VAS DEFERENS, which is also laid open to show the cellular structure which it assumes towards its termination.

F. The RIGHT VAS DEFERENS.

G G. The foramina, by which the vasa deferentia open into the common duct.

H. The lower and back part of the BLADDER.

I. The RIGHT URETER.

PLATE V.

This plate represents a section of the neck of the bladder.

A. The lower part of the urinary bladder near the neck.

B. The opening of the right ureter, which is marked 1. fig. iii.

C C. The substance of the prostate gland, which is cut through; its thickness, texture, and the manner in which it surrounds the beginning of the urethra, will be understood from this plate.

D. The urethra laid open.

F. The VERUMONTANUM, OR CAPUT GALLINAGINIS.

G G. The points of feathers put into the openings of the vesiculæ seminales and vasa deferentia.

N. B. Round these ducts, on the surface of the verumontanum, and in that part of the urethra which is surrounded by the prostate gland, innumerable mucous ducts may be observed: into some of these small bristles are introduced.

PLATE VI.

A view of the penis, vesiculæ seminales, and prostate gland.

OF THE

ORGANS OF THE SENSES.

OF THE SENSES.

INTRODUCTION.

THE brain is the seat of the mind; and certain mental changes are called perceptions. Those *changes* proceed, in the first place, from the operation of the organs of sense. The *organs of the senses* are so constituted as to admit the influence of things external to the body, while, through the connections of their nerves and the brain, they excite the mind to a condition corresponding with the external impressions.

It is in this manner, that through the organs of sense we receive those simple sensations which are the first elements of our thoughts, and the means of developing all the powers of the understanding. We never think of attending to the first simple intimations of the senses: before we are capable of reflecting on the nature of the perceptions which the several senses convey, they are so complicated and distorted by habits and association, that observation comes too late for us to ascertain the simple progress of nature.

To one who looks upon nature as a philosopher, there is a conviction that such researches may be carried too far. To whatever he directs his attention, to the changes of the globe itself, or to the structure of

the human body, to the physiology of vegetables, or to the phenomena of chemical science: whether he endeavours to comprehend the great system of the universe, or pores over the minutiæ of natural science, he finds every where a limit placed to his enquiries; a line which no industry or ingenuity can enable him to pass. We may please ourselves with conjecture beyond this limit, but we find our opinions nothing better than a dream of something allied to the impressions of our gross senses. The agency of external matter on the senses, the influence of the organs of the senses on the mind, and the influence of the will over the body, are mysterious, and, probably, inexplicable phenomena; yet we scruple not to explain them precisely and mechanically; we reduce them to the level of our own capacity, in the same manner as mankind have formed the idea of a Divinity by the combination of all human perfections. Yet, when we imagine that we have discovered the secret of these mysteries, it is mortifying to find ourselves without any sign or language by which to communicate those great truths to the companions of our studies! We struggle for expression; and, as all our ideas upon such abstract subjects are derived from analogy, we express our opinions respecting the powers of the mind, or the manner in which we perceive the objects of the senses, in the same language, and by reference to the same notions, which belong to the sensations themselves. From this scantiness and inaccuracy of language, it unavoidably happens, that very different ideas of the operation of the senses are expressed by several men in the same terms; and, in attempting to convey our ideas in language more precise and definite, we are insensibly led to materialise the faculties of the mind, and to make the operations of the senses merely mechanical. What other explanation can we give of theories, which suppose the nerves to be tubes carrying animal spirits, or containing an elastic ether; or which represent them as vibrating cords, and reduce all the variety of sensation to the difference of tension and tone? These are, indeed, what Dr. Reid calls them, "unhandy engines for carrying images."

Nothing has been undertaken in philosophy but entire systems, fathoming at once the greatest depths of nature. The custom has been to frame hardy conjectures, and if, upon comparing them with things, there appeared some agreement, however remote, to hold that as fully sufficient. What chimeras this method of philosophising has brought forth, it would be more invidious than difficult to specify.

The principles of philosophising have been laid down on this basis, that on no account are conjectures to be indulged concerning the powers and laws of Nature; but we are to make it our endeavour, with all diligence, to search out by experiment the true laws by which the constitution of things is regulated. In the subject now before us we have a very remarkable proof of the superiority of investigation by experiment over the lazy indulgence of conjecture; and I hope the whole tenour of the following account of the senses may serve, among other instances, to strengthen the conviction of the student, that it is only by assiduous study, and patient observation of nature, that he is to look for the attainment of knowledge in the medical profession.

The office of the brain and nerves is to receive the impressions of external bodies, by which corresponding changes and representations are made in the mind. We know nothing further than that, by the operation of the senses, new thoughts are excited in the mind. Betwixt the sensation excited in the organ of the external sense, and the idea excited in the brain, there is an indissoluble, though inexplicable, connection; the brain is not sensible, nor does the eye perceive, but both together give us the knowledge of outward things. But when the sensation is once received and communicated to the brain, it is treasured there, and may afterwards be excited independent of the external organ: hence comes the term internal senses; for by the act of the will a retrograde impression may be made on the organs of the outward senses, they may be excited by imagination, which is an effort internal, as well as by an impulse from without. It is very agreeable to reflect, that the soul is no more bound to the things around us than

is necessary to our present existence. It has powers independent of sensations; and the perceptions outlive the original cause of them in the influence of the organs of sense, and the material impulse which excites them. We are not creatures depending on external sensations merely; the impulse on our nerves is not the sole cause of our sensibilities: the conditions of the body itself furnish occasions of change to the mind; while many of its powers are possessed and brought into activity independent of the material impulse on the organs of sense. Perception first arises from external impulse; memory is the power of recalling these perceptions, and imagination the power of combining them, and there ultimately arises a wide field for the internal affections, without dependence on the system of material things. These powers of the mind are weak in infancy, for then the perceptions are feeble and transitory; but by exercise and experience they acquire strength, the memory becomes vigorous, the store of ideas is increased, but still we are in a remarkable manner tied down to the ideas received from the external senses.

At the same time, I would not have it supposed that this connection betwixt the state of the mind and the external senses is a necessary dependence of the former on the latter. Wherever it is necessary to the safety of the individual, to the production of the species, to the formation of societies, to the relation of man with his Creator; faculties are bestowed, and perceptions and sentiments arise in the mind independent altogether of the operations of the external organs of sense.

When the mental powers are led to the contemplation of an idea which assimilates easily with the sensation about to be presented by the external organ, the perception is quick and vivid; but when the mind is strongly impressed and occupied with the contemplation of past ideas, the present operation of the sense is neglected and overlooked. Thus the vividness of the perception or idea is always proportionate to the degree of undistracted attention which the mind is able to bestow on the object of sensation or of memory. In

solitude and darkness, the strength of the memory in the contemplation of past events is increased, because there is no intrusion of the objects of the outward senses; and the deaf or blind receive some compensation for their loss in the increased powers which are acquired by a more frequent and undisturbed use of the organs which remain, and a keener attention to the sensations which they present. On the other hand, when we are under the enchantments of a waking dream or reverie, our attention is wholly detached from the present objects of the senses. This state of absence, in a certain degree, is common and natural; it is the exercise of a faculty of the mind. But it may become disease; for the health of the mind consists in a balance of these powers, and a due correspondence betwixt the operation of the senses on the mind, and the efforts of the imagination independent of the senses.

The mind (united to the body) suffers in the diseases of the body. In the debility of the body, in fever, in spasms, and pain, the faculties of the mind languish, or are roused to unequal strength and to morbid acuteness of sensation. Sometimes the phantasms and internal sensations of things, formerly received by the outward senses, become so strong in the mind, as to be independent of the outward organ, and mistaken for objects actually present. Such frenzy or delirium arises from a disordered and acutely-sensible state of the internal senses. These impressions being great in degree, hurry and bustle is in the countenance of the patient, and uncommon strength and violence in his actions, just as passion gives great excitement to one in health, causing a disregard or forgetfulness of all besides. It is thus that internal perceptions become so strong as to be mistaken for realities, and attributed to the impression of real existences. While in health, during the exercise of imagination, there is a conviction that the ideas are not realities, and the operation of the external senses preponderates in recalling the attention to what is around us.

Sleep is another state of the animal system, fitting it for its condition. It is a state of comparative repose

and recovery. The child in the uterus sleeps always; the new-born infant sleeps a great deal; but, at length, the change of watchfulness and sleep appears to correspond with the revolution of our planet. Those, at least, will believe so, who perceive a correspondence in the weight of the body and the power of the muscles to the size and consequent attraction of the earth, and the condition of our fluids and circulation to the pressure of the atmosphere. During health, there are vicissitudes of consciousness and insensibility. This is true, however, only comparatively, and by a gross reference to degree; for even during natural sleep there is not a total oblivion of past perceptions, nor is there always a total unconsciousness of the present, as the senses are in part awake; some one train of ideas may be present to the mind, and the lapse of time may be observed. Even these perceptions are sometimes so strong as to be followed by voluntary exertion, and yet the person remains asleep.

Whatever conduces to take the excitement from the mind, or lessen the vivacity of its impressions, conduces to sleep. Thus, rest, stillness, and darkness, by excluding the most lively impressions conveyed by the senses; and hæmorrhage and evacuations, by lessening the velocity of the circulation; and cold, by lessening the sensibility, induce sleep. Again, compression of the returning blood from the head, by giving it a slow languid motion, and by depriving the vessels of their freedom of action, also conduces to sleep; because, as formerly remarked, the powers and faculties of the brain must be renovated through the means of the circulation; and by the diminished circulation there is a diminished sensibility, and therefore a weakness of impression on the external senses: all these consequences of impeded or diminished circulation, and consequent debility of the powers of the mind, should be distinguished from natural repose of the mind in sleep, a condition obviously imposed upon us, as I have said, in reference to the circumstances in which we are placed.

By long watching and fatigue, the body is brought nearly to a feverish condition. By sleep, rest is given

to the voluntary muscles, and an abatement of the vital motions ensues; the quiescent state of the muscles permits the blood to return to the heart, with a slow, regular, and calm progress; the heart is restored to its equable pulsation; the breathing becomes more gentle, and the wasted strength of the system is recruited. We may define sleep to be a state in which the sensations are dull, the voluntary muscles at rest, and the vital motions calm and regular.

In dreaming, the sensations are dull and obscure, but the imagination active.

In the soporific diseases the vital actions, which are calm and slow during natural sleep, become oppressed; and the sensibility (which is gradually diminished upon the approach of sleep, but always capable of being roused by the senses,) becomes quite oppressed; the voluntary muscles are relaxed, as in natural sleep, but sometimes convulsed by irregular motions.

In apoplexy, the faculties of the mind, and those powers of the nervous system which are placed under the guidance of the will, are suspended, while the vital operations proceed; and life continues until the derangement reaches the vital organs, which sooner or later happens, for the body is a whole, and part of it cannot exist separately in a state of activity.

Somewhat opposed to the state of apoplexy is that condition where the imagination is oppressed by some sensation, as in the night-mare, while the powers of motion are locked up.

If natural sleep is not profound, the imagination is awake; but there may be false perceptions, false judgment and associations, and disproportioned emotions; and when sensations are perceived, they do not produce the ordinary associations. If such a state of the intellectual functions occurs during the waking state, it becomes delirium. That this delirium is analogous to the perturbed state of the imagination during sleep, appears from the delirium in fevers uniformly showing its approach in the patient's slumbers. It is a disposition to form false images and associations, which, in the beginning, the excitement of the outward senses has

power to counteract, insomuch that a patient can be roused from delirium as he can be roused from sleep; but, by-and-by, the external senses lose their superiority, and their excitement is attended with unusual associations; they no longer convey impressions to the intellect, but become subservient to and modified by it, and the judgment, which depends on the due balance of memory and imagination, is lost. In fever, the delirium is transitory; in low fevers, it is combined with a comatose state; in melancholy, the delirium runs upon one object chiefly, or one train of ideas, which refer to the patient's health and corporeal feelings; in madness the variety is infinite, but chiefly consisting in a vitiated imagination and perverted judgment, with fierceness and increased power of corporeal exertion.

There are five organs peculiarly adapted to convey sensations to the mind; or, as I am more inclined to say, to rouse the faculties of the mind by exercising the internal organs of the senses in the brain: these may be considered as forming a medium of communication betwixt the external creation and the sentient principle within us; and in some measure the bond of union betwixt sentient beings. These organs are called the EXTERNAL SENSES; viz. the sense of seeing, the sense of hearing, the sense of smelling, the sense of tasting, and the sense of touch. If I were willing to break in upon received opinions in an elementary book, I would say that there is a sixth sense, the most important of all, the sense of motion; for it is by a sense of motion that we know many of the qualities of outward things, as their distance, shape, resistance, and weight. Individually, these organs convey little information to the mind; but by sensations received through them, by comparison, by combination or association, minister to the powers of the understanding, to memory and imagination, to taste, to reason and moral perception, to the passions and affections, and, in short, to the active powers of the mind.

OF THE ORGANS OF THE SENSES.

Let us not deceive ourselves into the belief, that by attention to this subject we shall be enabled to comprehend the nature of sensation, although the impression be made directly on the nerves of touch, taste, and smelling. We, perhaps, understand something of the body impressed; and we see the naked nerve on which the impression is made, and yet the effect is incomprehensible. In truth, when engaged in the study of the senses, we learn only how the strength of impression is increased, *e. g.* how the eye is calculated to transmit, and to accumulate, and to strengthen the impression on the nerve; or how the organisation of the ear increases the vibrations of sound; but of the nature of sensation we learn nothing.

OF THE EYE.

INTRODUCTORY VIEW OF THE PRINCIPLES OF OPTICS.

The organ of vision is a subject of general interest, every man of education studies it. That my reader may have a proper interest in it, we shall begin the investigation by an enquiry into the properties of light.

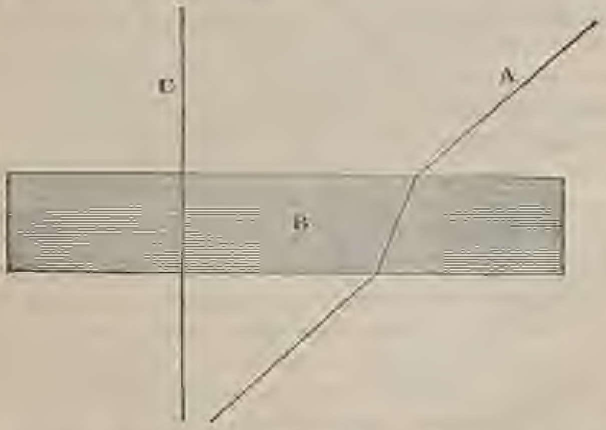
The grand source of light is the sun; but we may say, that light is a matter thrown out from ignited, or reflected from shining surfaces; which, entering the eye, and impressed on the nerve of that organ, gives the sensation of sight. The minuteness and inconceivable velocity of light, the facility with which it penetrates bodies of the greatest density and closest texture, without a change of its original properties, make it the source of the most wonderful phenomena in the physical world.*

The smallest stream of light which propagates itself through a minute hole, we may call a ray; and, as rays of light pass through a uniform medium in a straight course, they are represented in our diagrams by lines. But a ray is not simple; light is not uniform in respect of colour; every part of a ray is not capable of exciting the same idea when impelled on the nerve of the eye. White light is composed of different kinds of rays, which

* This is the Newtonian doctrine; but there are great names, as Hooke, Huygens, Euler, and Dr. Young, who support an opinion, that light results from the undulations of an ethereal medium pervading matter. On the truth of this I cannot decide, but the opinions of Newton form the more simple introduction to optics and to the structure of the eye. As to making the impression on the eye analogous to the impression on the ear, I would be inclined to turn the argument the other way, and say, that the senses are each of them endowed with a property of receiving distinct impressions from the qualities of matter which are dissimilar.

individually give a different sensation: one of red, another of orange, a third of yellow, a fourth of green, a fifth of light blue, a sixth of indigo, and a seventh of a violet or purple. These are named the prismatic colours; because, in the spectrum produced by making a ray of light to pass through a prism, these several colours are seen in the succession in which they are above enumerated. Each of these rays individually impresses the eye with its own colour; but, when they all impress the eye at once, the sensation upon the organ of sight is a compound effect; no individual colour is presented, but that mixed light which is called whiteness. Dr. Wollaston limits the prismatic colours to four — four primary divisions of the prismatic spectrum. These colours are *red*, *yellowish-green*, *blue*, and *violet*.

It is the nature of most bodies to attract these rays of light differently, and consequently to produce different colours. A body absorbs some of these rays of light, and reflects others from its surface; the colours of bodies depend upon the particular rays which are reflected from them, or upon the combination of such rays as are reflected from them; and therefore they appear of that colour of which the light coming from them is chiefly composed.



When a ray of light passes from a rarer to a denser medium, or from a denser into a rarer (as A into B), it

alters its course, if there be any obliquity in the original direction; but if it strikes from one medium into another perpendicularly to the surfaces (as C), its original direction is not changed. If the ray passing from the air enter obliquely into glass or water, or any denser medium, it turns more towards the perpendicular; but if it pass through the glass, and emerges again into the air, it resumes its original direction, diverging from the perpendicular. This effect of different mediums upon the ray of light is called refraction: when a ray of light impinging upon a surface does not enter, it rises again at an angle equal to the angle of its incidence; and this is reflection.

The prism is a piece of glass of a triangular form, of which we have here a section at A; the inclined surfaces of which, when placed in the course of the ray of light B, refract, and separate the several parts of the heterogeneous ray, and show its compound nature, C. If the sun be permitted to shine into a dark room through a small hole in the window-shutter, and the beam of light be made to fall upon a glass prism, it is, in passing through the glass, separated into its constituent parts; because the several coloured rays have different degrees of refrangibility, in the order in which I have already enumerated them. If the rays, after passing through the prism, be made to pass also through a convex glass, they are brought again to a point in the focus of that glass; and the effect of the whole colours, thus re-united, is perfect whiteness. We might suspect that the beams of light were homogeneous, and that the degree of refraction gave different colours to the rays, were it not proved, that how much soever any of the coloured rays is further refracted, it does not change its

nature; nor will rays suffer any change by reflection from bodies of different colours, for red lead will appear yellow, green, blue, &c. according to the colour of the ray of light directed upon it. It is found, that the coloured rays have not all the same power of illuminating objects: the orange ray possesses this property more than the red; the yellow more than the orange, &c.; and the maximum of illumination lies in the brightest yellow or palest green; nor do the several rays equally affect the thermometer.*

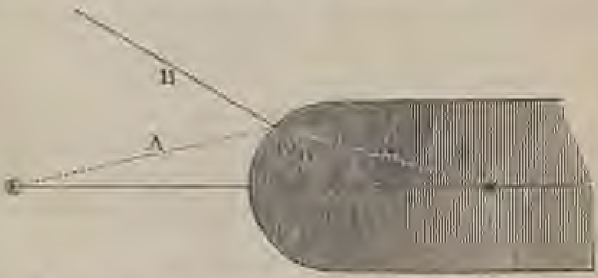
As the impression of light remains some time upon the nerve of the eye, it gave Sir Isaac Newton the opportunity of examining whether each coloured ray makes a distinct impression on the eye, or whether they so affect each other as to impress the sense of whiteness on the eye. When a burning coal is whirled in a circle, the eye perceives an entire circle of fire, because the impression made by the coal in any point of the circle remains until the coal returns again to the same place, and renews the sensation. When all the varieties of colours are painted in a circle, and turned in the same way with the burning coal, they must each make their separate impression upon the optic nerve; but the general sensation is whiteness; or, when the teeth of a comb are drawn across the stream of light issuing from a prism, the different colours are intercepted in such quick succession, that a perfect whiteness is the result of the mixture of impressions. There are many experiments which show that the inequalities of the refraction of light are not casual; that they do not de-

* This curious fact we owe to Herschell. He found not only that the prismatic rays had different powers, both of heating and illuminating objects, but that there were invisible rays beyond the red margin of the spectrum, which had no power of illumination, but only a power of heating. Other rays, invisible, but possessed of a chemical influence, have since been discovered, beyond the violet extremity of the prismatic spectrum.

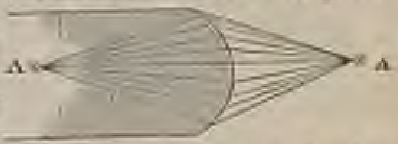
Light moves with inconceivable velocity: 195,000 miles in a second. How minute, then, must it be, to make no impression but on the appropriate nerve of the sense. See Herschell's Exp. Phil. Trans. 1800, p.ii. p.255.

pend upon any irregularity of the glass: on the contrary, it is proved that every ray of the sun has its own peculiar degree of refrangibility, according to which it is more or less refracted in passing through pellucid substances, and that the rays are not split and multiplied by the prism; but that rays originally constituted distinct, are separated by this instrument.

When a ray of light falls upon the surface of glass obliquely, it inclines to a line drawn (through the point of incidence) perpendicular to the surface.



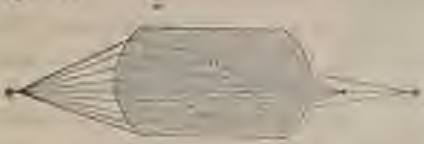
Thus the ray A, proceeding from the object, is refracted upon entering the mass of glass in the direction of the line B, having a tendency towards the perpendicular line. By this means, if a number of rays, proceeding from any one point, fall on a convex or spherical surface of glass, they will be inflected so as to gather about the perpendicular line A A, in the centre of the glass; which perpendicular line is the axis of the glass. If the rays of

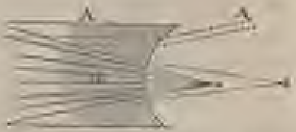


light proceeding from an object be made to strike into a mass of glass with a concave surface, the obliquity with which they impinge upon the surface, being the reverse of the convex surface, they are not made to converge upon the central line but diverge from it.

Farther, the rays of the sun, when passing from a medium of glass into the air, are turned, by refraction, farther off from the central line to which they were drawn in entering the convex surface of glass. But if

the rays, in passing through the glass A, were in a direction converging to the perpendicular line, they will be made to converge still farther, as is seen here in the figure.





If, however, the rays be made to pass from the glass B, into the air, and the surface of the glass be concave, the rays will be made to have a less degree of convergence, so as to remove the image * farther from the surface of the glass. But if the rays passing through the medium of glass have no convergence, but pass in parallel lines, they will diverge as the lines A A do, when they emerge from the concave surface of the glass.

We see, then, the operation of a double convex glass, in forming the image of a luminous body upon a surface. If, for example, such a glass be held between a candle and a piece of white paper (the distances being properly adjusted), the image of the candle will appear very distinctly upon the opposed surface, but inverted; because the rays coming from the point A converge at C, and those from the point B at D.

Before proceeding farther in this short exposition of the principles of optics, it will be necessary to take a very slight view of the structure of the eye, and let us apply these facts in explanation of its structure.

INTRODUCTORY VIEW OF THE STRUCTURE OF THE EYE.

The function of the eye is not simply to transmit the rays of light to the expanded optic nerve: it collects the rays and presents them in a small compass, the impression being stronger or more intense from the concentration of the rays. It is the first principle of the constitution of the eye, that the rays of light must be so concentrated as to impinge strongly on the expanded nerve or retina in the bottom of the eye. Now, as we have seen that a lens (which is a double convex glass) is necessary to concentrate the rays of light proceeding from an object, so as to form a small and lively image of it (as in the marginal plate), in the same manner an essential part of the eye is the lens, which brings the rays of light to a focus; and that the lens may make the rays proceeding from an object converge into an accurate focus, so as to form a distinct image on the eye, the vitreous humour is interposed betwixt the lens and the surface of the retina. Again, it is necessary to the constitution of the eye, that, in order to increase the sphere of vision, the anterior part of it shall project and form a large segment of a small circle, so as to take a greater circumference into the sphere of vision than could have been done, had the larger sphere of the eye-ball been continued on the fore part. Another necessary part of the apparatus of the eye is the iris, which is a curtain in the anterior chamber of the eye, perforated with a hole, which is capable of being enlarged or diminished, so as to admit a larger or smaller stream of light according to the intensity of the light. In this provision we see the necessity of the anterior humour of the eye being different from the others. It is a perfect fluid, a mere aqueous secretion, while the others possess a degree of firmness: thus the iris or curtain of the eye is permitted to move with perfect freedom in it.

The humours of the eye, therefore, are three: the aqueous, crystalline, and vitreous humours; and they stand in this relation:—

1. The AQUEOUS HUMOUR is the anterior humour of the eye. It distends the anterior and pellucid part of the eye, so as to increase the sphere of vision. It is perfectly fluid and of a watery consistence, that it may allow free motion to the iris.

2. The LENS OF CRYSTALLINE HUMOUR is placed immediately behind the perforation in the iris; which perforation is called the pupil. The lens collects the rays of light like a double convex glass, so as to concentrate them, and make a more forcible image on the bottom of the eye.

3. The VITREOUS HUMOUR is behind the lens. It distends the great ball of the eye into a regular sphere, that it may move easily in the orbit; and its diameter in the axis of the eye is so proportioned to the focal distance of the lens (affected also in some degree by the other humours), that the image of an object is formed accurately on the surface of the retina; accordingly, when the coats are cut from the back of the eye, the picture of a luminous object held before the pupil is seen exquisitely minute and distinct on the bottom of the eye.

While these humours have each its distinct character, they possess, in proportion to their density, different powers of refracting the rays of light. This has the still farther happy effect of correcting the dispersive powers of the humours, and giving the truest colours, as well as the most correct image of the object presented to the eye. It was not till the present day that the method was invented of correcting the false colours which form around the image of an object seen through powerful magnifying glasses; at last, Dolan invented the achromatic telescope, by compounding the lenses of two different kinds of glass. It is almost superfluous

to add, that the eye possesses this power, and in it the true colours only of an object are represented on the nerve of the eye. (See *Of the Lens.*)

If the lucid anterior part of the eye be formed too prominent, or if the lens of the eye have too great a degree of convexity, or, lastly, if the size of the ball of the eye, and consequently the diameter of the vitreous humour in the axis of the eye, be unusually great, then the person does not see distinctly; because the powers of the humours, in concentrating the rays of light, are too great, and the image of the object is not formed accurately on the retina, but before it. Thus the convexity of the cornea, the lucid anterior part of the eye, or the focal powers of the lens, being too great for the distance intervening betwixt the lens and retina, the image is formed at A before the rays reach the surface of the retina; and, after coming accurately to the point, they again begin to diverge; which diverging rays, striking the surface of the retina, give the indistinct vision of a near-sighted person. But as this indistinctness of vision proceeds from no opacity, but only the disproportion of the convexity of the eye to the diameter, the defect is corrected by the concave glass A; for, the effect of this glass being the reverse of the convex lens, it causes the rays to fall correctly upon the surface of the retina; that is, it corrects the too great convergence caused by the convexity of the humours. But, when a near-sighted person has brought the object near enough to the eye to see it distinctly, he sees more minutely, and, consequently, more clearly; because he sees the object larger, just as a person does when assisted with a magnifying glass or lens.

The near-sighted person sees distant objects indistinctly; and as the eye, in consequence, rests with less accuracy upon

the surrounding objects, the steady piercing look of the eye is diminished. Again, the near-sighted person knits his eyebrows, and half closes his eyelids: this he does to change the direction of the rays, and to correct the inaccuracy of the image, in a manner which may be understood by the following analogy. If we make a card approach a stream of light passing through the window, it will so attract the rays of light, as to extend the margin of the figure of the circular spot of light upon the wall. In the same way, when a stream of light, proceeding from an object towards the eye, is made to pass through a small hole, the circular margin of the hole so attracts the rays, as to produce an effect similar to the concave glass, or as if they proceeded from a nearer object; the image is carried farther back from the lens. When a near-sighted person peers through his eyelids, the margin of the eyelids or the eyelashes attract and disperse the rays in a certain degree. This corrects the imperfection of the humours, and the rays impinge more accurately upon the retina, and he sees more distinctly.

The effect of old age is gradually to reduce the eye to a less prominent state, and, consequently, to bring it to the reverse condition of the near-sighted eye; near-sightedness, therefore, diminishes with old age.

From the decrease of the humours, and the lessened convexity of the cornea, the image of objects is not formed soon enough to impinge accurately on the retina, the rays tend to form the image behind the retina, or they meet the retina before they have arrived at what is termed their focus.

In this figure, we have the effect of old age on the humours represented: without the intervention of the glass A, the rays have a direction which would form the image at some distance beyond the retina, as at B. But by the convex glass A (which is of the nature of the common spectacles for old people) the direction of the rays of light is so corrected, that the image falls accurately on the bottom of the eye.

We understand, then, whence these opposite defects of sight arise; that, in old people, objects cannot be seen distinctly when near, and, in short-sighted people, they cannot be seen distinctly when at a distance. We see, also, why old age corrects short-sightedness by gradually reducing the convexity of the eye, enabling the person to see objects farther removed, until, by degrees, he comes to see perfectly at the distance most convenient for the common affairs of life.

It has been, by some, thought extremely difficult to account for the image appearing to us, as it is in reality, erect, since it is actually figured on the bottom of the eye in an inverted position; but the terms above and below have no relation to the image in the bottom of the eye, but to the position of our bodies and the surrounding things. When I look to a tall man's face, I direct my eyes upwards; I observe his situation, as it relates to the area before my eye, or to a space in the sphere of vision. I know, after long experience, that I direct my eye; and it is the effort of direction, combined with the sensation of the retina, that gives the compound idea of the place of the object. Motion of the eye (if not produced by the voluntary effort of the proper muscles of the eye), conveys no idea; the image does not appear to move.

When an object approaches towards the eye, the diameter of the picture on the retina increases in the same proportion as the distance between the eye and the object decreases; and, consequently, it decreases in the same proportion as the distance increases. But the degree of brightness of the picture of an object on the retina continues the same at all distances, between the eye and the object, unless some of the rays of light are interrupted in their progress; for, as the advancing object becomes bright, it increases doubly in length and breadth, or quadruply in surface. The faint appearance of remote objects is occasioned by the imperfect transparency of the atmosphere.

There is nothing more astonishing in the structure of the eye than the sensibility of the expanded nerve, as proved by the extent of the changes or degrees of

light which illuminate visible objects, and of which the eye is sensible; or the great degree of light which the eye can bear, and the low degree of light at which objects are visible. Thus, the proportion betwixt the degrees of light illuminating an object by the sun, and by the moon, at any equal altitudes, is calculated at 90,000 to 1.* Again, by M. de la Hire's calculation, we see the sail of a windmill, six feet in diameter, at the distance of 4000 toises. The eye being supposed to be an inch in diameter, the picture of this sail, at the bottom of the eye, will be $\frac{1}{8000}$ of an inch, which is the 666th part of a line, and is about the 66th part of a common hair. This conveys to us an idea of the great sensibility of the nerve in accommodating itself to such varieties in the degree of illumination: it also proves to us that the expanded nerve must have a surface mathematically correct, on which the image is represented; for how else could the image of an object be distinct, if the picture of that object in the bottom of the eye be only the 66th part of a hair in diameter?

It is evident that some guard to the eye must be furnished, in order that the organ may accommodate itself to this surprising variety in the intensity of impression. The pupil of the eye is the central perforation in the iris or curtain, which hangs before the lens. This membrane, having muscularity, is moveable: it dilates or contracts the hole or pupil which transmits the rays, so as to adapt the diameter of the stream of light, darting into the eye, to the intensity or degree of light. If a body is illuminated but faintly, the pupil is (insensibly to us) enlarged, and a greater quantity of the rays are allowed to be transmitted to the retina. As the convexity of the pellucid part of the eye, and the concentrating powers of the lens, remain the same, the size of the image is not altered by this dilatation of the pupil, but only the strength of the image or picture in the bottom of the eye increased.

We have understood that the rays of light are refracted, when they pass out of one transparent medium into

* See Smith's Optics, vol. i. p. 29.

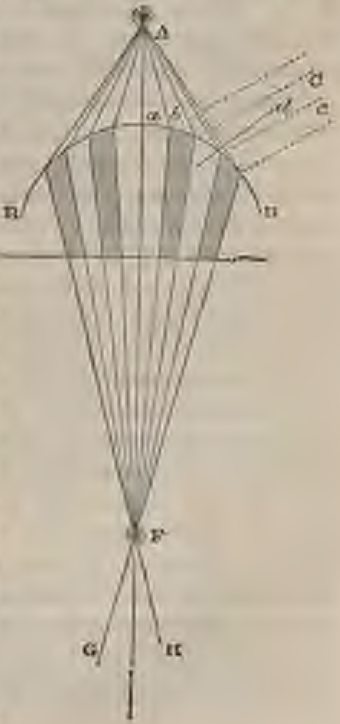
another of different density.—For example, the rays of light are refracted towards the perpendicular line when they enter the cornea of the human eye; but they will be refracted in a very small degree in entering the cornea of fishes, because the aqueous humour is of the same density with the fluid from which the rays of light are transmitted; accordingly, the cornea of fishes is not prominent: it would be of no use. On the other hand, this would limit their sphere of vision, were not the deficient convexity of the cornea counterbalanced by the prominence of the whole eye, and the more anterior situation of the crystalline lens in the eye: a large pupil and greater convexity of the lens we shall afterwards find to be necessary to the distinct vision of fishes.*

It is natural, on the present occasion, to enquire into the effects of the several humours of the eye, in producing in those who are short-sighted the obscurity arising from the double appearance of small and shining points. This is prettily explained by Jurin, upon Sir Isaac Newton's principle, concerning the fits of easy refraction and reflection of light.

The horns of the new moon, or the top of a distant spire, or the lines upon the face of a clock, appear doubled or tripled, and sometimes much more multiplied, to a short-sighted person. The same appearance will be given when an object is held too near the eye for perfect vision. If the light is seen through a narrow slit in a board, and the board is brought nearer to the eye than the point of distinct vision, the aperture will appear double, or as two luminous lines, with a dark line between them; and as the distance is varied, two, three, four, or five dark and luminous lines will be observed. There are many such deceptions in viewing

* Neither fish out of water, nor other animals within water, can see any object distinctly. Divers see objects, as an old man would do, through a very concave glass put near to the eye; and it has been found, that the convexity of spectacles for divers in the sea must be that of a double convex glass, equal on both sides to the convexity of the cornea. The necessity of this is plain; the aqueous humour of the eye being of the same density with the water, there is no refraction of the rays in passing from the water into the eye, and this deficiency must be supplied.

luminous bodies; all of them proceed from the same cause, which is this:—Before Sir Isaac Newton's philosophy was acknowledged, it was the received opinion, that light was reflected from the surface of bodies by its impinging against their solid parts, and rebounding from them like a tennis-ball when struck against a hard and resisting surface; further, as they saw that part of the rays of light were in glass reflected, and the rest transmitted, they conceived that part entered the pores of the glass, and part impinged upon its solid parts. But this does not account for the refractions which take place when the rays have passed the glass, and are about to be transmitted into the air: they cannot find solid parts to strike against in entering the air, for the refraction of the light is greater in passing from the glass into the air, than from the air into the glass; and if water be placed behind the glass, the refraction of rays passing out from the glass is not increased but diminished by this substitute for the rarer medium of the air. Again, when two glasses touch each other, no refraction is made in rays passing from the one into the other. To explain this, Sir Isaac Newton taught, that, in the progress of rays of light, there is an alternation of fits of easy transition or reflection; or, in other words, that there is a change of disposition in the rays, to be either transmitted by refraction, or to be reflected by the surface of a transparent medium. Jurin illustrates this opinion, and its application to our present purpose, in this manner.



Suppose that A B D, and B D F, are media of different

density, and that their surfaces are intersected by the line B D; again, let A be a pencil of rays, which, issuing from this point, falls upon B *a* D, as the refracting surface B *a* D is convex, and no two points of it, from *a* to D, are equally distant from the source of the rays A; and, as the rays of light, in their progress, alter alternately from the fit of refraction to the fit of reflection, they must be in part refracted to the focus F, and reflected in the direction of the dotted lines C *c*. Thus, if the ray A *a* happens to be in disposition to pass through the medium B D F, it will pass on towards the point F. If the next ray, A *b*, should not be in a fit to be transmitted, because, being in a degree farther advanced from its source A, it has changed to the fit of reflection, then it will not be refracted towards the focus F, but reflected off towards *c*; but, again, the ray A D being advanced farther from its source, it will impinge upon the surface B D, during its disposition to refraction, and will concentrate its beams at F; and so with all the others, alternately reflected and refracted.

The consequence of this obstruction to the equal refraction of light, is, that the image formed at F is feeble; but still it is distinct and perfect; because the transmitted rays are regularly concentrated, and form the proper focus. But if the converging rays should be received upon a plane before they arrive at the focus F, the reflected rays of light will have left spaces dark where they would have fallen by refraction, and, consequently, distinct luminous circles will be thrown on the plane: again, if the plane surface be opposed to the rays, after they have formed their focus, and are again dispersing after having crossed, the same unequal effect of light and dark circles will be thrown on it; though now, the rays of the right side of the pencil B D F, will form the left of the pencil F G H.

The effects of the alternate disposition of the rays for transmission and reflection would not be perceptible, did the converging powers of the cornea and lens bring the focus of the rays exactly to the surface of the retina, as in the perfect eye. But in the near-sighted person the focus is formed at a point before the retina, the

rays decussate and spread out again before they form the image upon the bottom of the eye. Instead, therefore, of forming an accurate image, they are spread out into concentric circles; or, in a lesser degree, the person experiences a confused outline of the object, which becomes surrounded with several rings or false outlines.* This subject must be studied under the head of Polarisation of Light, in our philosophical books.

OF THE ANATOMY OF THE EYE STRICTLY.

THE COATS of the eye are divided into three classes.

1. The anterior and external coats; viz. The CONJUNCTIVA and the ALBUGINEA.

2. The proper coats; viz. The SCLEROTICA, the CHOROIDES, the RETINA.

3. The transparent tunics of the eye.

As the first class belongs to the external apparatus of the eye, we shall begin with the PROPER COATS.

Speaking generally, and without considering the minuter divisions of anatomists, we may say, that there are three proper coats of the eye; viz. the SCLEROTIC COAT, giving strength; the CHOROID COAT, being the vehicle of the chief vascular structure of the eye; and the RETINA, or expanded nerve, being the seat of sense. These are the proper coats of the eye.

Although these coats may be capable of being divided by the art of the anatomist, either by the knife, by injections, which form extravasation between their layers, by maceration, or by the chemical action of fluids; yet it is better, in a general enumeration, to take a natural division, than to enumerate all their subdivisions.

* By *fits of easy transition*, it was not meant by Sir Isaac Newton that the rays must necessarily be transmitted through every pellucid medium, and at any obliquity of incidence, but only that the ray was more easily transmitted, and more difficultly reflected; nor was it meant that, during its *fit of easy reflection*, it was absolutely incapable of being transmitted, but only more readily reflected than transmitted.

OF THE SCLEROTIC COAT.

The sclerotic coat is so called from its hardness.* The sclerotica and cornea are often considered as one continued coat investing the eye; hence they say, the opaque and the lucid cornea. But, although these parts are actually in union, yet, as they are really of so very different a nature, we must consider them apart, and treat at present only of the opaque white sclerotic coat.

The sclerotic coat is a strong, firm, and white membrane, consisting of lamellæ firmly attached and interwoven, and not capable of being regularly separated by maceration: it has the denseness of tanned leather. In firmness, whiteness, opacity, and the little appearance of vascularity, it more resembles the dura mater than any other membrane of the body.

In adults, the sclerotic coat is stronger and firmer, comparatively, than in the fœtus; the cornea less so. On the outer surface, it has (towards the orbit) a loose cellular membrane attached to it, which allows the motion of the eye-ball. Upon the fore part it is invested by the tunica albuginea or tendinea. Upon its inner surface, it has a loose and soft membrane which connects it with the choroid coat.

In birds, and the tortoise, the posterior part of the sclerotic coat is thin; the fore part of it is split into laminæ, betwixt which there are interposed thin plates of bone †, while in fishes it is in part cartilaginous ‡, but thin and transparent, so that there appears a very beautiful spotted coat beneath it. There are also seen in the sclerotic of fishes little white granules like glands.

The vagina of the optic nerve can be separated into two laminæ §; the outer one is observed to unite intimately with the outer part of the sclerotic coat, while the inner lamina of the vagina is contiguous with its inner surface. The pia mater, too, says Zinn, when

* Dura seu sclerotica. Vesalius, Ruysch, &c.

† Cuvier, vol. i. p. 387.

‡ Morgagni Epist. An. xvi. 40. Cuvier, 388.

§ Ruysch, Zinn.

it has pierced the foramen in the sclerotic coat, along with the substance of the nerve, expands upon the inner surface of this coat, and extends even to the cornea, and forms one of its intimate laminæ. This must be only that part of the pia mater which invests the optic nerve, or, more strictly speaking, that membrane which stands in the same relation to the nerve that the arachnoid coat does to the brain; for the membrane, which sinks into intimate union with the nerve, accompanies it even in forming the retina.*

The sclerotic coat is the great support of the globular figure of the eye: it defends the more delicate internal structure from slighter injuries, by its strength; and from the progress of inflammation, by being of a structure but little vascular, and not prone to disease. That inflammation which we see to be so frequent in the eye, is not in the sclerotica, but in the adventitious coat, the conjunctiva. But in proportion as the sclerotic coat resists pressure and the progress of disease from without, it resists the swelling of the parts within when they become diseased, and gives the greatest torture.

Of what importance the entireness of the coats, and the uniform resistance of the humours of the eye, is to the healthy state of the organ, will be afterwards examined.

* It may be well, in this place, to mention the opinions of the chief supporter of that scheme of the coats of the eye, which derives them all from the investing membranes of the brain and optic nerve. M. le Cat, in his *Traité des Sens*, describes them thus: — When the optic nerve has entered the orbit, the dura mater which surrounds it splits into two laminæ: the external one attaches to the orbit, and forms the periosteum; the other forms the vagina of the nerve. In the angle formed by these, the muscles of the eye arise. This continued sheath of the nerve (he continues) expands into the globe of the eye, as the mass of glass is blown into a bottle. The dura mater of the nerve is expanded into the cornea (viz. sclerotica.) The second envelope, or pia mater, forms two laminæ; the one is applied to the sclerotic coat, and the other forms the choroid coat. The choroid coat divides anteriorly, and forms the iris and ciliary processes. The internal medullary part of the optic nerve forms the retina. Finally, "L'œil est très évidemment l'extremité nerveuse épanouie boursouflée en bouton creux et plein de liqueurs," p. 158. See also *Bonn* Sandifort Thesaur. de Continuatione Membranæ.

OF THE CORNEA.

The cornea is so called from being firm, transparent, and composed of laminæ.* It is the pellucid circle on the fore part of the eye which seems variegated with colours; though this is a deception, owing to its perfect transparency. The circle of the cornea is, however, far from being regular; its margin is flat towards the nose. The cornea, being a segment of a smaller sphere than the eye-ball, enlarges the field of vision. The field or sphere of vision is further extended by the motion of the eye. The motion of the eye has a range of 55 degrees in every direction; so that there is altogether a range of 110 degrees.†

The cornea consists of laminæ; betwixt which there is interposed a cellular substance, filled with a perfectly pellucid fluid.‡ These cells seem, like the common cellular membrane of the body, to have a free communication with each other, so that the fluid freely exudes, and as quickly is imbibed by maceration. The fulness of the cornea, with the perfect transparency of the fluid, gives a brilliancy to the eye, and is a sign of health; the reverse dims the eye, and with the fallen features accompanies ill health. Steno observed, and Petit confirmed the fact §, that the pores on the surface of the cornea exuded the fluid which fills the cells of the cornea; and that, after the surface was carefully dried by pressure, the moisture might be seen to form in drops upon the surface. The moisture can be thus forced out from the pores of either surface of the cornea.‖ This moisture becomes dull and clammy on the approach of death, and forms sometimes a pellicle over the cornea. The laxity with which the laminæ of the cornea are connected, may be, in some measure, demonstrated, by taking it betwixt the finger and the thumb; we shall

* "Cornu modo, dura, et cornu instar in laminas dividareque potest." Vesalius.

† Dr. Young, Phil. Trans. Nov. 27. 1800.

‡ Substantia spongiosa Valsalvæ.

§ See also Hovius, p. 82.

‖ Zinn.

then find, that the layers can be made to glide very freely on each other. In the fœtus, and in young children, the cornea is of great thickness, and resists the point of the lancet or scissars. This resistance in the fœtus proceeds from a great degree of toughness, while, in the adult, the surface of the cornea is so hard that I have often seen the point of the knife, in extracting the cataract, bend upon it. This turning of the elastic point of the knife is very apt to give a wrong direction to the incision.

There is a pellicle, or exceedingly thin coat, which, by maceration, can be taken off from the surface of the cornea. This is the conjunctiva continued over it.

The membrane in fishes, analogous to the adnata, lies loose over the cornea; and, in serpents, it is thrown off from the cornea, with the scales of the body, and remains attached to the cast skin of the head; and, in the fœtus calf, I have forced the blood in the vessels of the conjunctiva into the vessels passing over the surface of the cornea.

By maceration, I have found, raised in the fluid, a very delicate and transparent membrane from the inner surface of the cornea *; and, after long-continued soaking, the whole cornea can be taken out of the sclerotic coat, like an optician's glass from its frame.

The cornea possesses great sensibility; although much of the pain, from hard bodies flying into the eye, is to be attributed to the motion of the eye-lids, and the great sensibility with which they are endued. When a splinter of glass or metal strikes and sticks in the cornea, inflammation is excited: in consequence of this, vessels carrying red blood strike into it, or shoot over its surface in a new film or membrane.† Petit thought he

* This, within these few years, has been claimed as a discovery. I fear that this must be considered as the capsule of the aqueous humour long since described.

† I have found the spark from iron in blacksmiths and masons buried in the cornea for several days (some authors say months), without exciting pain or much inconvenience. I have also more than once picked a little black slough from the cornea, mistaking it for a piece of iron, when it was only the consequence of the injury.

observed first in a negro, and afterwards in a variety of instances, red lines in the cornea, which he conceived to be the anastomosing of vessels. There are, besides, says he, many circumstances which argue that there are blood-vessels in the cornea. When the eye receives a stroke there is often blood effused in its substance; abscesses, also, are found within it, and phlyctænæ are seen on its surface; and, in great inflammation of the eye, the cornea appears red; which, he supposed, must be produced by the same cause which makes the albuginea red, viz. the enlargement of its vessels, and the circulation of red blood. But we must not imagine, he continues, that, in the natural state, red blood circulates in the cornea; for the vessels are not to be seen with the microscope; nor are they penetrated by injection; nor do they appear in the fœtus; nor, when little abscesses are formed in the cornea; but only when violence has been done by a stroke upon the eye. In an eye in which the tunica conjunctiva was minutely injected, as well as the internal vessels of the eye, I observed through the microscope a set of vessels, but which, on reflection, I believe to have been only the cellular communication betwixt the laminæ of the cornea.

Vessels attach themselves both to the inner and to the outer surface of the cornea; and when it becomes spongy and vascular in this way, little can be explained of its natural structure. Thus, the pannus and pterygium are membranes which stretch across and adhere to the cornea, while the iris frequently attaches to its inside. In this case, the cornea becomes spongy, thick, and vascular; and, when cut, there is red blood in it *; and in staphyloma †, the iris is generally attached to the cornea. I have a preparation in which the form and character of the iris are entirely lost: it is extended

* Pterygium is a disease of the conjunctiva, but which resembles a membrane extended over the cornea from the canthus. Pannus is a disease of the same kind, but covering the cornea as with a white opaque membrane.

† Staphyloma uvea, viz. a protrusion and opacity of the cornea; which, from the loss of transparency, and the general appearance of the tumour, is supposed to resemble a grape.

into a reticulated membrane which lines the surface of the extended cornea.

OF THE CHOROID COAT.

The choroid is the vascular tunic of the eye: it is so called from its resemblance to one of the membranes of the secundines. It is the middle coat of the eye, lying betwixt the sclerotic coat and retina. Injections show it to consist of two layers or membranes; and it has upon its inner surface a pigment, which, being sometimes firm, might be taken for a membrane. It was Ruysch who observed this division of the choroid coat into two laminæ; and the inner one his son called the tunica Ruyschiana: but of these hereafter.

Those anatomists who supposed the sclerotic coat to be the production of the dura mater, naturally concluded, that the choroid coat was derived from the pia mater; and as Ruysch found it to be divisible into two laminæ, so Sladius found the pia mater to consist of two membranes. It followed that the one lamina of the choroid coat was the continuation of the tunica arachnoides, and the other of the pia mater; but this account of these membranes has no support from observation. Betwixt the pia mater and choroid coat there is no resemblance; the latter we shall find loaded with vessels: but these vessels are peculiar, and minister to a secreting surface. The pia mater in the brain, and optic nerve, is in strict union with the substance of the brain, and supports and nourishes it; but the choroid coat has no connection with the retina or expanded nerve.

There can be no better mark of distinction between membranes than their degree of vascularity, and particularly in the manner of the distribution of their vessels. The choroid coat is most particular in the distribution of its arteries and veins. The great arterial vascularity of the choroid coat is to be seen only after a very minute injection, and the venous vascularity after artificial or accidental infarction of the blood, or by a

successful injection from the superior cava*; although the very great vascularity of this coat was known to our oldest writers, yet the appearance of these vessels, when empty, has deceived many. Morgagni† and Maitre-jean have described fibres which they affirm to be distinct from the vessels, but which prove to be, in fact, the appearance presented by the collapsed vessels.

The great peculiarity of the choroid coat is its being a secreting membrane; by which I mean that the pigmentum nigrum, which is applied to the fine external membrane of the retina, being a secretion, the choroid coat has necessarily that peculiar structure of vessels which belongs to the secreting membranes. This structure has enabled anatomists to tear it into laminæ. For that part of the choroid coat next the sclerotic is merely a vehicle of vessels and nerves, and is a tissue of them connected by very fine cellular membrane. The internal part, again, is organised into a secreting surface, and is the tunica Ruyschiana.‡ I conceive, that the division into the choroid coat, and tunica Ruyschiana, is warranted from the nature of the membrane, as the divisions of the coats of the intestines are.§

Morgagni says, that, from his earliest youth, he had many proofs that the choroid coat was not single in brutes; he asserts, also, that Franciscus Sylvius and Guenellonius had demonstrated the double laminæ of this membrane before Ruysch.‖ Certain it is, that Ruysch was not so fortunate in ascribing a use to this tunica Ruyschiana. He supposed that it gave strength to the choroid coat, and, by bringing a greater afflux of arterial blood, supplied the necessary heat to the otherwise cold humours.¶

* An observation of Walter.

† Morgagni Epist. Anat. xvii. 2.

‡ Ruysch. Epist. Anat. xiii.

§ Albini Annot. Acad. lib. vii. cap. iv.

‖ Morgagni Epist. Anat. xvii. 3.

¶ Quod ad usum tunicæ Ruyschianæ attinet crediderim hanc tunicam inter cæteros usus esse destinatam, non solum ad robur choroidæ, verum etiam ut a sanguinis arteriosi majori copia requisitus calor

Tapetum. — The internal surface of the choroid coat has been long called tapetum, from its villous or fleecy appearance when seen through the microscope. This surface in the adult is of a brown colour; in very young subjects it is red and bloody; and, when minutely injected, it is like scarlet cloth. It is by this vascular surface or tapetum that the black pigment, which is laid under the expanded retina in the human eye, is secreted.

The pigmentum nigrum. — The pigmentum nigrum is the black or deep-brown mucous substance which lies between the choroid coat and retina. It is of a nature to be washed away with a little water and a soft pencil.* This brown taint pervades the whole texture of the choroid coat. It is in immediate contact with the exterior membrane of the optic nerve. Its use is apparently to stifle the rays of light after they have struck on the sensible surface of the retina; for we know that blackness is owing to the absorption of the light, as whiteness and colour is the reflection of it from the surface of bodies. The dark colour of the secreted pigment of the choroid coat is, in some measure, peculiar to those animals which see in the brightest light of day; but is wanting, or of a bright reflecting green or silvery whiteness, in such as prowl by night. The natural conclusion, therefore, is, that the pigmentum nigrum subdues the intensity of the impression, while the reflecting colours of the surface in animals which see during the night, strengthen the effect of the

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tribus humoribus natura frigidis conciliaretur. Ruys. Respons. ad Christ. Wedelium, p. 14.

* I cannot conceive how this matter should be confounded with the tapetum or tapis, which, as the name implies, is the villous surface of the choroid coat. Tapetum is, properly, cloth wrought with various colours; and the analogy was first used by the French Academicians, in the account of their dissection of a lioness. "The membrane "which is put into the bottom of the eye, and laid on the choroides, "which we call the tapetum, was of an Isabella colour, intermixed "with a greenish blue. It was easily separable from the choroides, "which remained entire, with its ordinary thickness, after that we "had taken away the membrane which forms the tapetum." The explanation of this, I suppose, will be found in Morg. Epist. An. xvii. 3.

light on the surface of the retina, by repelling it. As fishes have the other provisions for seeing in an obscure light, they have also this of the reflecting surface of the tapetum: as it is a secretion of the villous surface of the choroid, we see why it becomes somewhat deficient in old men, and sometimes wanting in the degenerate varieties of animals; when entirely deficient, the blood circulating in the vessels of the choroid coat gives a lurid redness to the reflections from the bottom of the eye.*

Finally, in regard to the choroid coat, we have to understand that it consists of two laminæ: the outer, and that which is next to the sclerotic coat, being the proper choroid; the internal lamina, the tunica Ruyschiana: that on the surface of the tunica Ruyschiana there is a pile or fleece, which is called tapetum: and, lastly, that the secretion of this inner surface is a pigment, which, in the human eye, has the appropriate name of pigmentum nigrum; but, in many animals, it is of a silver, golden, or Isabella colour; though, in my apprehension, the colour, in all these varieties, depends still upon a peculiar secreted matter.

ANNULUS LIGAMENTOSUS.

When we take away the sclerotic coat from the choroides, we see at the termination of the choroides, forward in the iris, a white ring: this should be called the ciliary ligament: it is the bond of union betwixt the choroid coat, the iris, and corona ciliaris. Soemmering calls this the annulus gangliformis tunicæ choroideæ.

* As the pigmentum nigrum is a secretion, we shall not be surprised to find it become deficient in the commencement of some diseases of the eye. This is known by the possibility of seeing to the bottom of the eye; that is, the choroid coat becomes a reflecting surface, and throws out the beams like a cat's eye. See Med. Observ. and Enquiries, vol. iii. p. 124.

OF THE CILIARY PROCESSES, OR CORONA CILIARIS.

The ciliary processes are formed of the anterior margin of the choroid coat: they give the appearance as if the choroid coat, at the anterior part, were folded inward to the margin of the crystalline lens; and as if, to accommodate it to this sudden inflection, it had been plaited, and not regularly contracted; at least, this is much the appearance of the circle of ciliary processes, when, after cutting across the eye, we look from behind upon the lens in its natural situation. In this view, we find the pigmentum nigrum of the choroid coat continued over the ciliary processes, which gives to them the appearance of the regular plicæ of the choroid coat, converging to the edge of the lens, and forming altogether a disk round it.

When the black paint on the ciliary processes is a little washed away, and when we attentively examine this part, we find the ciliary processes to be actually little oblong plicæ, which gradually arise from the choroid coat at the angle of its inflection, and terminate abruptly, approximating, but not attached, to the margin of the lens. When the paint is washed entirely away, the whole circle of these processes appears evidently to be the continued choroid coat.

When not injected, the ciliary processes are pale and loose; but, when minutely injected, they take a perfect scarlet colour; they resemble, in their uninjected state, the valvular-like doublings of the villous coat of the stomach and intestines. Before the choroid coat is inflected towards the lens, in the form of ciliary processes, it forms a firm adhesion to the sclerotic coat near the circular margin of the cornea, and at the same time is united firmly to the root of the iris forming the annulus ligamentosus. From this, the processes tend inward, and a little backwards; and are, at their external extremities, detached from the iris; nor are they attached to the margin of the lens, but are loose and floating.

When the vitreous humour and lens fall out from the

anterior segment of the eye, we find that the plicæ or ciliary processes have left their impression on the anterior surface of the vitreous humour, and also on the intermediate expansion of the retina which extends before the membrane of the vitreous humour. This circular impression of the ciliary processes is called by Haller, striæ retinæ subjectæ ligamento ciliari.* I have called this impression HALO SIGNATUS, because it is produced by a circle of radiations, formed by the impression of the ciliary processes, and is not peculiar to the retina, for the retina again makes its impression on the membrane of the vitreous humour. The furrows and doublings of the anterior part of the retina, formed by the impression of the ciliary processes, Dr. Monro has called the ciliary processes of the retina; but, for my part, I think this a term likely to confound and mislead a student; and we might as well speak of the ciliary processes of the vitreous humour, or of the membrane of the vitreous humour, since they also take the impression of the ciliary processes.†

When the vitreous humour and lens are taken out of the coats, we see also that the ciliary processes have left the stain of the black paint.‡ This it is necessary to remark, since I have seen students confound this mark with the ciliary processes themselves. The ciliary processes are of a most elegant vascular structure. Their contorted arteries are beautifully represented in Zinn's figure. He traces them from the extreme branches of the choroid coat; but, of their veins, he says nothing further than that they are continued from the branches of the vasa vorticosa, or veins of the choroid coat. The points of the ciliary processes are

* Fasc. vii. icon. ocul.

† Winslow uses the term sulci ciliares, for the impression on the vitreous humour. Zinn calls this corona ciliaris, after Camper: he describes them well, p. 75.

‡ See Morgagni Epist. Anat. xvii. n. 13. and Ruysch also, "Nonnulli pro processu ciliari agnoscunt pallas pigmenti nigri reliquias, membranulæ tenuissimæ humoris crystallini et vitrei, et quasi fibres mentientes, oculo sc. aperto, humoribusque exemptis; hæ autem nil sunt nisi avulsæ particulæ pigmenti nigri." Ruysch. Thes. An. ii. Ass. 1. No. xv.

not attached to the lens, but float loose in the posterior chamber of the aqueous humour *; but, at a little distance from their points, they adhere to the retina, where it is continued over the anterior part of the vitreous humour. Through this attachment only are they connected with the lens; for, as we shall find presently, the retina (as a membrane, but not as the sensible retina,) is continued over the crystalline lens.†

SOEMMERING [*Icones oculi humani*] describes the retina as spontaneously falling off and separating from the exterior circle of the *corona ciliaris*. But he also has mistaken the nervous matter which stops here for the whole retina. The transparent tunica vasculosa retinæ proceeds to the lens.

The ciliary processes, collectively, form a circle round the lens, which I call corona ciliaris. This circle forms a perfectly opaque partition, which stifles all rays that might otherwise be transmitted by the side of the lens. The corona ciliaris, or ciliary circle, no doubt, serves at the same time as a connection between the outer and strong coats of the eye and the transparent coats and humours; for, it is to be observed, that, excepting the connections which naturally exist between the optic nerve and retina, this slender hold which the ciliary processes take of the expanded retina, is the only attachment betwixt the humours of the eye and the proper coats.

In regard to the names appropriated to this part of the eye, there is more confusion than it is possible to believe. It is necessary to attend to this ambiguous use of terms, else we shall be in danger of misunderstanding our best authors. Vesalius considers the whole as a septum betwixt the vitreous and posterior chamber of the aqueous humour; but he seems to find much diffi-

* This was demonstrated in a particular manner by Ruysch and Morgagni.

† Zinn and other later writers have entertained the idea that the adhesion of the ciliary processes to the membranes covering the vitreous humour is by a kind of gluing, rather than a union by cellular membrane. See Zinn, p. 75.

culty in giving it an appropriate name.* Fallopius and Morgagni† use the term CORPUS CILIARE for the whole circle of the processes, and in the same sense that I have ventured to use corona ciliaris. It is a name which conveys the idea neither of the shape nor of the substance of the thing meant. Ruysch makes great confusion by his use of terms: the corona ciliaris, or ciliary body, he calls the ligamentum ciliare; and the lines on the back surface of the iris, he calls processus ciliaris musculosus; or, rather, he means by this, the straight fibres of the iris.‡ Duverney, with Ruysch and Winslow, following Fallopius, calls the corona ciliaris also ligamentum ciliare. But the ciliary ligament is used by others in a widely different sense, viz. for the circular root of the ciliary body and iris, the annulum album cellulosum, or the frenula membranosa of Zinn. By Hovius, what I have called halo signatus is called ligamentum ciliare. In Haller's fifth figure of the eye, this circular root of the ciliary processes is called orbiculus ciliaris. Maîtrejean, Haller, and others, call the whole body, or corona, the ciliary circle; M. Ferrein, "l'anneau de la choroide;" and M. Lieutaud denominated the ciliary processes, "rayons ciliares," and the root of the corona ciliaris and iris, "plexus ciliaris."

OF THE IRIS.

The iris is the coloured circle which surrounds the pupil, and which we see through the transparent cornea

* "Neque mihi ullum occurrit nomen quod ipsi aptius indam quam tunicæ; aut, si voles, interstitii vel septi inter vitreum humorem et eum quem albugineum nuncubamus repositi." Vesal. vol. i. p. 558.

† Epist. Anat. xvii. 11.

‡ Ruysch has this expression:—"Ligamentum ciliare neutiquam esse considerandum tanquam musculum ad pupillæ et humoris crystallini motum destinatum, totumque hoc negotium perfici a processu ciliari ut et a circulo musculari posterius in confinio pupillæ sito." Thes. Anat. ii. xv. See also the explanation of fig. iv. of this Thesaurus, where we have, "Iris enim est facies exterior, processus lig. ciliaris facies interior."

of the eye. It is a membrane hung before the crystalline lens.* It is perforated in the middle; and this hole in the middle of the iris is the pupil; and through the pupil only can the rays be transmitted to the bottom of the eye. When we hear of the dilatation and contraction of the pupil, it is an inaccuracy of language: we have to understand the action of the iris, which, by possessing the power of contracting and spreading out, diminishes or enlarges the pupil, and so holds a control over the quantity of light transmitted to the bottom of the eye. For, by the extension of this membrane, the diameter of the pupil is diminished, and by contraction of the membrane it is enlarged. This motion of the iris, and, consequently, the size of the pupil, is connected with the sensation of the retina; by which means, in disease of internal parts of the eye, it is often an index to us of the state of the nerve, and of the possibility of giving relief by operation.

The iris and corona ciliaris, or ciliary processes, are, in general, considered as being the two laminæ of the choroid coat, continued forward and split: the internal lamina of the choroid forming the corona ciliaris, and the outer one forming the iris. The former I was willing to consider as the anterior margin of the choroid coat, because it has no distinction in its structure from that coat; but the iris I cannot consider as the continued choroid coat; in the *first* place, because I have found it fall out a perfect circle by maceration; *secondly*, because it has no resemblance in structure to the choroid coat; and, *chiefly*, as, by its power of contracting, it shows quite a different character from any of the other membranes of the eye.

* Winslow and Haller, and most of the old anatomists, call this UVEA; by which they mean to imply that it is a part of the choroides. See Ophthalmographia, Auctore G. Briggs, Cantab. 1676: but most of the modern anatomists follow Zinn and Lieutaud in calling it iris; though Lieutaud and others call the anterior surface only iris, while they still continued to call this perforated membrane choroides, or uvea. See Lieut. p. 117. Again, others call the posterior surface of the iris uvea, from its likeness to the dark colour of a raisin; and the word iris is borrowed, I suppose, from the varied colours of the rainbow on its anterior surface.

The outer surface of this circular membrane gives the colour to the eye during life; and, from its beautiful and variegated colours, it has gained to the whole membrane the name of iris. Haller and Zinn, nearly at the same time, explained the cause of this colour of the iris, which had been, till then, supposed to be occasioned by the refraction of the light amongst its striæ and fibres. When this membrane is put in water, and examined with the microscope, its anterior surface is seen to be covered with minute villi. The splendid colouring of the iris proceeds from the villi; but, by beginning putrefaction, the splendid reflection fades, as the brilliant surface of the choroid of brutes is lost by keeping. For this reason, I imagine the colour and brilliancy of the iris to depend on the secretion from these villi. But the colour of the iris depends, in a great measure, on the black paint upon its posterior surface shining through it; and the black and hazel-coloured eye is owing to the greater degree of transparency of the iris, which allows the dark uvea to shine through it.

The iris is acknowledged to be the most acutely-sensible part in the body. We have, then, to expect in its composition muscular fibres, and to account for its acute irritability and sympathy by a profusion of nerves: again, as the power of the muscular fibre, and the sensibility of the nerve, are both, in some measure, indebted to the circulation of the blood, we may expect to find also a profusion of vessels in the iris. In all these respects we shall find the iris to be an object of admiration.

OF THE MUSCULAR FIBRES OF THE IRIS.

It is evident from a note, under the head corona ciliaris, that Ruysch had observed two sets of muscular fibres in the iris; for, under the name of ciliary ligament, he describes a set of radiated fibres which go from the ciliary processes towards the circular margin of the pupil: he observed, also, the circular or orbicular fibres which run round the margin of the pupil. Winslow says, that between the two laminæ of the uvea (viz. iris)

we find two thin planes of fibres, which appear to be fleshy: the fibres of one plane orbicular, and lying round the circumference of the pupil, and those of the other being radiated; one extremity of it being fixed to the orbicular plane, the other to the great edge of the uvea. Zinn describes, with much minuteness, radiated fibres (on the anterior surface of the iris), but does not consider these as muscular fibres; and he confesses, that he could not observe the orbicular muscle which Maîtrejean and Ruysch had painted. Even in owls and other creatures, having a strong iris, he could not discover an orbicular muscle; nor were Haller and Morgagni more successful in this investigation.* Wrisberg also affirms, that no muscular fibres could be seen in the iris of the ox. Dr. Monro, on the other hand, adheres to the opinion of the muscularity of the iris: he describes minutely both the radiated and sphincter fibres. Wrisberg and others have thought they found sufficient proof against the muscularity of the iris, in the fact of its not contracting when the light falls upon its surface. To this Dr. Monro answers, that the colour or paint upon the iris must, like a cuticle, prevent the light from irritating the iris. I cannot think that this circumstance should prevent the excitement of the iris. The retina is in a peculiar manner susceptible of the impression of light; but we cannot wonder that light should not stimulate a muscle to contraction, when we have every proof that it has no effect on the most delicate expanded nerve of the other senses.

That the iris is to be affected only through the sensation of the retina, communicated to the sensorium, we have sufficient proof. I have, in couching, repeatedly rubbed the side of the needle against the iris without exciting any motion in it; I have seen it pricked slightly by the needle without its showing any sign of being irritated; nay, what was, too, a convincing proof, I have seen it cut by falling before the knife in

* See Zinn, p. 89. and 90. Morgagni Epist. Anat. xvii. § 5. Haller and Ferrein attribute the motion of the iris to an afflux of humours in its vessels.

extracting the cataract. In this last instance, far from being stimulated to contraction, it hung relaxed.*

It is evident, then, that no common stimulus, immediately applied to the iris, has any sensible effect in exciting it to contraction; and that it is subject to be influenced, in a secondary way, by the degree of intensity of light admitted to the retina. The movement of the iris is in general involuntary; but terror and sudden fright effect it. In some animals, particularly in the parrot, it is a voluntary muscle.† As an object upon which we look approaches the eye, the pupil contracts, which is an effect of the increasing intensity of the light reflected from the object; for, as we observed before, as the object advances, it fills a greater space in the sphere of vision, and, of course, more rays flow from it into the eye.

Nerves of the iris.—The iris is supplied with nerves in great profusion. They are derived from the long ciliary nerves which run forward betwixt the cornea and choroid coat towards the common root of the corona ciliaris and the iris. They there divide, and are seen to pass in numerous branches into the substance of the iris. In the substance of the iris, the branches of the nerves, from their extreme minuteness, are soon lost amongst its pale fibres.

Blood-vessels of the iris.—I have had preparations which showed so great a degree of vascularity in the iris, that I was ready to believe its action to be produced entirely by a vascular structure; but when, on other occasions, my admiration was excited by the profusion of nerves, and I was led to observe that in the

* This fact destroys the hypothesis of M. Mery, of the Royal Acad. of Sciences, that the straight fibres of the iris are little cavernous bodies, and that the action of the light upon the retina swelled and elongated them so as to cause the diminution of the size of the pupil; for, by this cut, they must have fallen from their erected state, and contracted so as to have dilated the pupil. See Acad. Roy. des Sc. 1704, Mem. p. 261.

† When a cat is roused to attention, as by the scratching of a mouse, it dilates the pupil, which allows a stronger impression on the bottom of the eye; nay, whenever puss struggles violently to get loose, the pupil dilates, which may sufficiently account for M. Mery's cat having her pupil dilated when he plunged her under the water. See Acad. Roy. des Sc. 1704, Mem. p. 261.

former instances they had been obscured by the injection, I could not but allow that the muscular fibres might have been obscured as the nerves were.

There are four arteries sent to the iris: two long ciliary arteries, which take a long course on the outside of the choroid coat; and two lesser and anterior arteries, which pierce the ligamentum ciliare from without. These arteries approach the root of the iris at four opposite points, and, branching widely, form a vascular circle round the root of the iris, viz. the larger circle of the iris. From this circle branches pass off, which run with a serpentine course, converging to the edge of the iris: here they again throw out inosculating branches, which form a circle surrounding the pupil, but at some little distance from the edge of the iris;— this is the lesser circle of the iris. From this lesser circle there again proceed minute branches towards the edge of the iris.*

The VEINS, which intermingle their branches with these arteries, pass some of them into the vasa vorticosa of the choroid coat, and others take a long course betwixt the choroid and sclerotic coat, accompanying the ciliary nerves; whilst some branches pierce the sclerotic coat at the root of the iris, and become superficial upon the fore part of the eye.

It was at one time believed, on the authority of many excellent anatomists, that the vessels of the iris were colourless, and did not circulate red blood: after what has been said, it is scarcely necessary to notice the fallacy of this opinion.† I have seen the iris cut and bleeding, though not profusely, as I expected; the small quantity of blood soon coagulated into a dark speck, while I expected it should have been effused in the aqueous humour.

* See Ruysch. Epist. Anat. Prob. xiii. p. 31.

† Dr. Monro, in treating of this subject, mentions his having seen a network of vessels covered with paint darker than that of the iris, and extended from the iris upon the surface of the lens; and, in another instance, a network of filaments passing quite across the pupil. See his Dissertations, p. 108.

OF THE RETINA,

AND DIGRESSION CONCERNING THE SEAT OF VISION.

The term retina has, in a modern publication, been objected to, as improperly applied to the inner coat of the eye. Such a term, it has been said, may well be applied to the nerve expanded on the lamina spiralis of the cochlea, because it is there formed into an intricate plexus by innumerable joinings and separations of its component parts; but, used for the expanded nerve of the eye, the term retina is thought improper.* We must look for the resemblance, however, which justifies this term, not in the medullary matter of the nerve, but in its vessels. "Hanc figuram egregie repræsentat dicta tunica retina cum arteriolæ ceracea materia sunt repletæ." †

The retina is the expansion of the optic nerve, the immediate seat of sensation, and the most internal of those membranes which are called the coats of the eye. It has been already observed, that there is a distinction betwixt a nerve in its course from the brain to the organ of sense, and where it is actually expanded and adapted to the reception of the external impression. Before the optic nerve has perforated the sclerotic coat of the eye, it is surrounded with a firm sheath; and its substance is evidently composed of bundles of fibres, though not so coarse, yet like those of the nerves in the other parts of the body. The opacity of the nerve makes it have little the appearance of vascularity; but, when the body of the nerve is made transparent, it becomes like a red cord; so necessary is it that the medullary substance of the nerve be supplied with blood.

The stronger sheath which surrounds the body of the optic nerve is loose, and may be separated into lamellæ.

* Dr. Monro's 4to. Treatises.

† Ruysch. Epist. Anat. xiii. p. 14. Quamobrem servare adhuc retinæ, appellationem si non ex fibrarum ut certe ex vasorum implicatione, &c. Morgagni Epist. Anat. xvii. § 48.

There is a more delicate membrane, which immediately adheres to the surface of the nerve; and its substance is formed into the minute fasciculi, which give it the fibrous appearance by a still firmer intertexture of membrane. This interwoven membrane proceeds, with the retina, into the eye; the other sheaths are reflected off, and unite with the sclerotic coat. Some little way from the back part of the eye, the arteria centralis retinæ pierces the sheath of the nerve, plunges into the centre, and passes into the eye along with it. If the optic nerve be cut near to the eye, the open mouth of this small artery may be seen; but if we make our section some way removed from the back of the eye, it will, of course, not be seen. The space left by the artery contracting in the centre of the nerve, when thus cut, (or, perhaps, it was the open mouth of the artery itself,) was observed by the ancients, and by them called the porus opticus: they were ignorant of this central artery of the retina.*

Where the optic nerve is about to enter into the ball of the eye, it is much diminished in diameter: it is contracted and condensed, and, at the same time, lays aside the strong coats. The proper nerve then perforates a cribriform lamina in the sclerotic coat. Within the eye, the filaments seen in the nerve are no longer distinguishable; but from the extremity of the nerve the fine web of the retina is produced.

The LAMINA CRIBROSA, and the delicate fasciculi of the optic nerve, are shown in this manner: after making a section of the eye, wash away the retina from the extremity of the optic nerve, and also the choroid coat; then press the optic nerve betwixt the finger and thumb, when the pulp of the nerve will be seen to protrude through the foramina in the sclerotic coat like white points. It is observed by Zinn, that, in doing this, there is a central foramen which remains unfilled up by the compression of the nerve. This is the hole per-

* Porum opticum Hierophilus et omnis ab ea antiquitas dixit, foramen nempe quod in dissecto nervo de vacua arteria superest. Hall. Arter. Ocul. Hist. p. 42. De Vasis Nervi Optici, vide Ruysch. Epist. Anat. xiii. tab. xvi. Albinus Acad. Anat. lib. vii. c. vii.

forated by the arteria centralis retinæ.* Where the threads of nerves are accumulated after passing these foramina, and before they are finally expanded into the retina, they necessarily form a small cone or papilla. This conical form of the extremity of the optic nerve is much more evident in some animals than in others; but in a section of the human optic nerve we may also observe it.†

The retina is a membrane of the most delicate texture of any in the animal body: it is transparent in the recent state, and so soft, that it will tear with its own weight. In spirits and weak acids, it becomes opaque and firmer. It lies expanded over the vitreous humour, and contiguous, but not adhering, to the choroid coat, or its pigment. The retina does not consist merely of the expanded nervous matter, but has in its composition two very fine membranes, and many minute vessels. This part of my subject brings me to the beautiful discovery of Dr. Jacob of Dublin, of a new membrane or layer of this coat of the eye. If the sclerotic and choroid coats of the eye be dissected off a recent eye, and the retina disclosed, and especially if this be done under water, a fine film may be seen to rise and float from the outer surface of the retina. The pulp or proper nervous matter of the retina is retained between the two membranes, the tunica vasculosa retinæ on the inside, and the newly-discovered membrane on the outer surface. Zinn, it may be perceived from the note below, had no idea of such a separation being possible. When the retina is macerated for a considerable time, the pulp of the nerve can be washed away, and there remains only the reticulated and delicate membrane, which supports the vessels that nourish it. But, though the pulp of the nerve may be dissolved, it cannot,

* Zinn de oculo humano, p. 106. Com. Reg. Soc. Scient. Gotting. loc. cit. About thirty foramina have been observed in the lamina cribrosa. See Haller Fasc. de Arter. Oculi, p. 42.

† Zinn. "At the place which answers to the insertion of the optic nerve, we observe a small depression, in which lies a sort of medullary button terminating in a point." Winslow, p. 78.

by dissection, be freed from the membranes which support it on the inside. *

I have a preparation which more resembles some of Ruysch's plates than any I have seen; in it, the nerve being washed away, we may see distinctly the whole course of the arteria centralis retinæ. Of this preparation I have given an engraving, to show how plentifully this organ is supplied with red blood; from which circumstance we may learn the strict dependence of its function on the circulation, and sometimes we may deduce the derangement of the powers of vision as a consequence of the disordered action of these vessels.

The outer membrane of the retina is transparent, but the proper matter of the nerve is opaque in the dead subject, and the opacity of the nervous matter prevents the vessels of this coat being seen when we look upon the outer surface † for the vessels of the retina run upon the surface contiguous to the vitreous humour. ‡ The arteria centralis retinæ is derived from the ophthalmic artery. It pierces the optic nerve, as we have already observed, and enters the eye through the porus opticus, to supply the retina. But the arteries of the retina do not always enter into the eye in one trunk;

* "Posse vere medullarem retinæ laminam removeri ut vasculosum rete membranæ figuram retineat, alteramque ab altera integram detrahi ultra hominum artem positum esse videtur nec ulli unquam contigisse legere me memini, etsi, deleta macerando medulla, rete vasculosum laminam peculiarem referre videatur. Ex quibus omnibus elicio retinam esse tunicam simplicem, ex cellulosa conflatam: que vascula et substantiam medullarem sustinet etsi duas diversas ostendat facies alteram vasculosam interiorem, alteram medullarem exteriorem." Zinn, p. 112.

† "C'est surtout dans les poissons qu'il est facile de distinguer, et même de séparer, ces deux lames." Cuvier, tom. ii. p. 419.

The opacity of the outer surface of the retina prevents the vascularity from being apparent. Albinus, after a very minute injection, observed, that when he lifted up the choroid coat, the vascularity of the retina was not seen: "Autem de ea aliquid acuto scalpello subtiliter levissimeque deradens, mox conspicio vasa impleta multa quæ sub medulla cujus nimirum portionem deraseram latuerant." Albin. An. Acad. lib. iii. cap. xiv.

‡ Dr. Monro has these words, expressive of an opposite opinion: "The whole appears to be composed of an uniform pulpy matter, on the outer side of which chiefly vessels are dispersed, supported, I suppose, by a membrane the same or analogous to the pia mater." 4to. Treatises on the Eye, Ear, &c.

on the contrary, sometimes two or three branches pierce the lamina cribrosa *, and afterwards, two, three, or four principal branches, spread out on the circumference of the retina; from these, the ramifications are so numerous, that Ruysch describes them as constituting the membrane.† Corresponding with the arteria centralis retinæ in the adult, there are veins, the minute extremities of which, after forming connections with the veins of the corona ciliaris, run backwards on the inner surface of the retina in three or four distinct branches. These, uniting into a trunk, perforate the lamina cribrosa, and become the sociæ arteriæ centralis.

Many have been led to believe, that the retina terminates forward on the roots of the ciliary processes; others have conceived it to be continued over the fore part of the vitreous humour, and over the surface of the lens. ‡ The most prevalent opinion is, that it terminates on the margin of the lens. Correctly speaking, there is no termination to a proper membrane: I know no instance of it. That the retina, considered as the organ of sense, extends over the back of the lens, and receives there the impression of light, is very improbable; but that the membrane, which supports the nervous matter, is continued over the lens, is demonstrable. I have said above, that the retina consists of two distinct parts, viz. the medulla of the nerve, and pellucid membranes supporting it. It is by most anatomists believed, that the retina passes forward betwixt the vitreous humour and corona ciliaris, and adheres to the margin of the lens. Now, as this adhesion is not a gluing together of parts, but a union or intermixture of membraneous filaments,

* Haller loc. cit. Morgagni Ep. Anat. xvii. n. 44., nor do they always pierce the centre of the nerve exactly. Morgagni.

† "Iteratis perscrutiniis reperio oculis armatis arteriolarum extrema tam esse numerosa et tam arcte sibi invicem et intricate annexa ut peculiarem repræsentent membranulam ex arteriolarum extremis constitutam, cui connectetur dicta medullosa substantia." Ruysch. Epist. Anat. xiii. p. 15.

‡ Many anatomists, Winslow, Cassebohm, Ferrein, Lieutaud, and Haller, have taught that the retina extends over the great convexity of the lens, or that it is inserted into it. Galen believed it to extend over the lens. For an impartial history of opinions, see Morgagni Epist. Anat. xvii. 47. and Zinn, 114.

the interchange and mingling of fibres, we may safely say, that the membrane of the retina is continued over the lens, and forms part of its capsule. The opacity of the retina is diminished at the root of the ciliary processes, and disappears altogether at the margin of the lens; and here it is not only changed by becoming perfectly transparent and allied to the membranes of the humours, but it becomes also distinguishable from the opaque retina by a greater toughness and strength. The continuity of the retina with the capsule of the lens is more apparent, when both membranes have become opaque by being immersed in spirits or vinegar, but more particularly when that opacity is produced by disease. In disease, I have found the veins of the retina running over the margin of the lens, and branching on its posterior convexity.

THE FORAMEN OF SOEMMERRING.

When a student in Edinburgh, I found, on dissecting a recent human eye, a yellow spot on the retina of an irregular figure. I noticed that it was opposite the pupil, and conceived it to be a disease of this part of the nerve. I preserved the preparation carefully. When the discovery of Soemmerring was made known to me I found my mistake, and that this curious spot was a natural appearance.* Soemmerring describes the appearance as a foramen, surrounded with a yellow edge. But it is not a foramen: the pellucid membranes are not *perforated*; the appearance is a consequence of the imperfect opacity of a point in the centre of the yellow spot. He describes, too, a fold, which hangs over the hole, and tends to conceal it. In my preparations, the foramen is on the prominence of this fold. The existence of this fold in the living eye has been disputed. Blumenbach thinks he has got a use for this *hole*. He supposes that it expands and contracts: but how this is "to prevent

* Soemmerring De foramine centrali limbo luteo cincto retinæ humanæ. — *Comment. Soc. Reg. Scien. Gotting.*

the inconvenience of too intense a light," I cannot, as yet, comprehend.*

Where the retina lies betwixt the vitreous humour and the ciliary processes, it is plaited, and descends into the interstices of these processes.

When we take off the sclerotic and choroid coats of the eye, by dissecting them round the insertion of the optic nerve, and fold them back, carefully preserving the retina; and, when we have taken away the ciliary processes from their adhesion to the fore part of the retina, we find the retina to form a sac surrounding the vitreous humour, and attached to the lens. In all this surface the membrane is smooth and uninterrupted, and up to the margin of the lens all this sac is opaque; because the nervous matter contained betwixt the membranes is opaque, but the coats of the lens are transparent, yet continuous with the arachnoid portion of the retina. When these parts of the eye are thus dissected, they hang all together by the optic nerve; viz. the lens, the vitreous humour, and the expanded matter of the nerve, and the organ is divested only of its outer apparatus: we still retain within this sac the more essential and important parts.

There is here a natural division; and I am willing to pause upon this, knowing well with how much difficulty the student gains a knowledge of the minute structure of the eye. All within the connections of the retina

* The *foramen* of Soemmerring, or *foramen centrale retinæ*, was discovered by Baron Soemmerring in the human eye, about the year 1795. He described at the same time a yellowish margin, partly surrounding it, and a fold of the *retina* close to it. The structure was at first supposed peculiar to man, but was soon after shown by Cuvier and Michaelis to be present in the *Quadrumana*: it has since been discovered by Dr. Knox to be present in the *Cameleon*, and in certain species of the lizard, as the *Lacerta superciliosa*, &c. The *foramen* is larger in the *Cameleon* than in man: it occupies the same relative situation with regard to the entrance of the optic nerve, and is exactly in the line of vision. The margin is not yellow. Dr. K. affirms, that the fold generally described in the human retina is a *post mortem* appearance. See his papers in the Transactions of the Royal Society of Dublin, and of the Wernerian Society of Edinburgh.

I shall call the INTERNAL GLOBE of the eye, as distinguishing it from the outward coats of the eye, and parts subservient to them. A view of the little vascular system of these internal parts, thus classed, will show how strictly they are connected together, and how much insulated from the other parts.

But this is a subject upon which we cannot enter until we have considered the nature and relative situation of the humours of the eye.

DIGRESSION ON THE SEAT OF VISION.

M. l'Abbé Marriotte discovered the curious fact, that when the rays fall upon the centre of the optic nerve, they give no sensation. He describes his experiment in this manner: — "Having often observed, in dissections of men, as well as of brutes, that the optic nerve does never answer just to the middle of the bottom of the eye; that is, to the place where the picture of the object we look directly upon is made; and that in man it is somewhat higher, and on the side towards the nose: to make, therefore, the rays of an object to fall upon the optic nerve of my eye, and to find the consequence thereof, I made this experiment. I fastened on an obscure wall, about the height of my eye, a small round paper, to serve me for a fixed point of vision; I fastened such another on the side thereof towards my right hand, at the distance of about two feet, but somewhat lower than the first, to the end that I might strike the optic nerve of my right eye while I kept my left shut. Then I placed myself over against the first paper, and drew back by little and little, keeping my right eye fixed and very steady upon the same, and, being about ten feet distant, the second paper totally disappeared." *

This defect in the vision of the one eye is corrected by that of the other; for the insertion of the optic nerves being towards the side next the nose, no part of an

* Vide Phil. Trans. No. 35. Smith's Optics, Remarks on, art. 87.

image can ever fall on the optic nerve of both eyes at once; the defect of vision, therefore, is observed only in very careful experiments. Experiments were, however, made by M. Picard, Marriotte, and Le Cat, to render this effect produced by the image falling on the centre of the optic nerve evident, when looking with both eyes. Marriotte's second experiment was this:— Place two round pieces of paper at the height of your eyes, three feet from one another; then place yourself opposite to them at the distance of 12 or 13 feet, and hold your thumb before your eyes at the distance of about eight inches, so that it may conceal from the right eye the paper that is to the left hand, and from the left eye the paper to the right hand. If, now, you look at your thumb steadily with both eyes, you will lose sight of both the papers.* The novelty of such a discovery was likely, as frequently is the case, to carry men's minds beyond the true point. It requires time for such facts to descend to their level in the scale of importance, with other less novel observations. Marriotte, upon this fact, formed a new hypothesis relating to the seat of vision. We have observed, that the choroid coat and pigmentum nigrum are deficient where the optic nerve enters the eye and is about to expand into the retina. He fixed upon the most unaccountable supposition, that the retina does not receive the impression of the rays, but that the choroid coat is the seat of the sense. In support of this theory, he soon found other arguments than those arising from the deficiency of the choroid coat at the entrance of the nerve. He saw that the pupil dilated in the shade, and contracted in a more intense light: now, says he, as the iris is a continuation of the choroid coat, this is a proof of the great sensibility of that coat: again, the dark colour of the choroid

* Dr. Smith made the stream of light through the keyhole of a dark chamber fall upon this point of the retina, opposite to the termination of the optic nerve, but he found it quite insensible even to this degree of light. M. Picquet asserts that very luminous objects make a faint impression on the centre of the optic nerve. But Dr. Priestley says, that a candle makes no impression on that part of his eye.

coat he supposed to be well calculated for the action of the rays of light, which are not reflected from it, or transmitted, but absorbed; while, on the other hand, the retina is transparent. If vision were performed in the retina, says Marriotte, it seems that it should be found wherever the retina is; and since the retina covers the whole nerve, as well as the rest of the bottom of the eye, there appears no reason why there should be no vision in the place of the optic nerve. M. Picquet argued in opposition to Marriotte. He observed, in regard to the fitness of the black colour of the choroides for the action of the rays of light, that the choroid is not universally black; that there are many shades of difference in the human eye; and that it is black, blue, green, yellow, or of a metallic shining surface, in a variety of animals. He conceived that the defect of vision at the insertion of the nerve is occasioned by the blood-vessels of the retina.* He observed, also, that the opacity of the retina is such, as necessarily to obstruct the transmission of the rays of light to the choroid coat. M. De la Hire took part in this controversy. He considered the retina as the organ of sight, although a particular point of it is not susceptible of immediate impressions from outward objects; for, says he, we must not conceive sensation to be conveyed by any other means than by the nerves. But, observing the constitution of the other organ of the senses, he entertained an idea that the retina receives the impression in a secondary way, and through the choroides, as an intermediate organ; that, by the light striking the choroid coat, it is agitated, and communicates the motion to the retina: and we find that through all the organs of the senses, he continues, the nerves are too delicate to be immediately exposed to the naked impressions of external bodies.

Another objection to the opinion, that the retina is the seat of sensation, has been lately urged, viz. that the

* Against this hypothesis, the size of the insensible spot was urged by Marriotte. Bernouilli calculated that this spot is a circle, the diameter of which is a seventh part of the diameter of the eye, and that the centre is twenty-seven parts of its diameter from the point opposite to the pupil, and a little above the middle.

thickness of this coat, together with its transparency, allows of no particular surface for receiving the image; and that its transparency would cause a partial dispersion, which would produce a confusion in vision.*

If these opinions require serious refutation, we have it in the effects of the diseases of the retina, optic nerve, and brain. But the thalami nervorum, the optic nerve, and its expansion into the retina, seem scarcely to have ever occurred to these speculators as worthy of notice in this investigation.

The following appears to me the true account of this matter. The outer or posterior surface of the retina (being that which is towards the newly-discovered membrane) is the proper seat of vision. That it must be a *surface* on which the object is represented, is evident from the consideration of the extreme minuteness of the objects painted there. Now, it is to be considered that at the point where the optic nerve comes through the coats of the eye, there is no posterior surface peculiarly adapted to receive the impression of light; and as well might we expect the optic nerve to be sensible to the impression of light in any point of its extent from the brain to the eye, as at this; for here the inner surface of the retina only is formed: there is no posterior surface upon which the rays can impinge. The doubts regarding the cause of this spot giving no sensation, have arisen from the idea, that the internal surface of the retina, or its substance, felt the impression of the rays of light.

At the same time it is evident, that the choroid coat, and its secretion, is in a most remarkable manner subservient to the retina, as the instrument of vision; for, when the secretion is black, it absorbs the rays; and animals which have such a pigmentum nigrum see best during the full day: again, when the surface is of a shining nature, it repels the rays, and this contributes

* M. Le Cat thought the pia mater was the sentient part of the nerve. It was, therefore, a kind of confirmation of his opinion to suppose the choroid to be the seat of vision, as he teaches that the choroid coat is a production of the pia mater. He conceived that the retina moderated the impression of light upon the choroid coat, as the cuticle dulls the impression on the papillæ of the tongue.

to strengthen the sensation; and such animals are fitter for seeing in obscure light: nay, further, if the surface of the choroid be coloured, the animal will see objects of that colour the best, because the colour of the choroid depends upon its reflecting more of the coloured ray than of the others of which light is composed.

But as animals see which have no paint on the choroid, (neither such as will absorb, nor such as will strongly reflect the rays,) and which have merely the surface of the choroid with its coloured blood-vessels in contact with the retina; so it is evident, that it is not the deficiency of the choroid coat, nor the want of the black paint at the entrance of the optic nerve, which prevents the sensation, but, really, that there is here no surface formed and organised to receive the impression of the light, the internal surface not being the sensible surface of the retina.

FURTHER OBSERVATIONS ON THE RETINA.

It has already been observed, that vision is the combined operation of the external organ, nerve, and brain; consequently, the destruction of the function may be produced by disease of the retina, of the optic nerve, or of the brain. Any partial injury, pressure, electricity, or galvanism, influencing the retina, will cause the sensation of light or fire before the eye.* Because here, or in its corresponding part of the brain, is the organ of vision; and no idea but of light is this organ capable of exciting in the mind. Disease in the retina, nerve, or corresponding part of the brain, causing total blindness, while the cornea and humours of the eye remain pellucid, is called AMAUROSIS. It is, in general, to be considered as a paralytic affection. Amaurosis † has been

* Light from pressure on the eye. See Cartesius, cap. ix. lib. de Meteor, and the Ophthalmographia of Briggs, *Cornea*.

† AMAUROSIS; GUTTA SERENA; CATARACTA NIGRA; which last name is from the blackness of the pupil in consequence of the transparency of the lens.

found to follow strokes on the head; concussion and compression of the brain; blood effused within the skull; or tumours pressing on the nerve or brain.* An amaurosis spasmodica has been enumerated by authors. This kind of blindness has been supposed to arise in consequence of the stricture of the optic nerve by the origins of the recti muscles: as far as I have observed, no action of these muscles can affect the optic nerve before it perforates the coats of the eye. If it were to be attributed to the operation of these muscles, I should rather suppose it to be occasioned by their spasmodic action on the ball of the eye, by which the function of the retina may be disordered; but I think it is more probable that the same irritation which is acting on the motory nerves of the eye, does, in this instance, affect also the optic nerve and retina. However, distention of the coats of the eye, by increased secretion of the humours, destroys the sensibility of the retina. In the hydrophthalmia, there is in the beginning a short-sightedness, so that objects are seen only when near the eye. Thus far we might account for the defect of vision by the alteration of the focus of the cornea and humours; but by-and-by, as the eye enlarges, as it becomes turgid, and the coats more distended, the pupil becomes stationary, and the vision is lost before the aqueous humour has become turbid.†

* "Ipse vidi bis in puerulis scrophulosis amaurosin, etiam subito ingruentem; secto cadavere inveni glandulam strumosam nervis opticis incumbentem." *Sauvages Nosol.* From many observations we find that tumours and extravasations, which must compress gradually, do yet produce an instantaneous effect.

In Bonetus§, we have many cases of blindness from abscess in the anterior part of the brain; from fluid on the surface, and in the ventricles; from steatomatous tumours; from coagulum of blood, and from a hydatid pressing on the union of the optic nerves; and, lastly, from a calculus in the optic nerve. For a case of blindness from pressure upon the eye and its displacement, and consequent elongation of the optic nerve, by an encysted tumour in the orbit, with gradual recovery after operations, see *Med. Ob. and Enquir.* vol. iv. p. 371.

† Luxation, or displacement of the eye, by tumours, causes blindness, by extending the optic nerve or compressing the eye-ball, and consequently the retina.

§ De Ocul. Affectibus, Ob. 2.

The connection and sympathy betwixt the retina and the viscera of the abdomen is very particular. We have proofs of this in the disorder of the stomach having an immediate effect on the sensibility of the retina. Allied to this, but greater in degree, is the amaurosis, which attacks hysterical women suddenly, with headache and violent pain. From such sympathy of parts arise the amaurosis biliosa, verminosa, intermittens, arthritica, &c. Similar attacks of blindness have been found to alternate with convulsions.*

Commencing cataracts and opacities of the cornea, and of the humours in general, give occasion to spots and obscurities in the vision; but we have at present to consider those only which depend on the state of the nerve. Errors of vision are not easily to be distinguished from those of the imagination proceeding from the brain; error opticus, or hallucinatio, from delirium: one distinction of the former is, that we can correct the deception by the assistance of the other senses, while in the latter, the mind is disturbed.

Old people are often troubled with the appearance of dark irregular spots flying before their eyes. In fever, also, it is very common to see the patient picking the bed-clothes, or catching at the empty air. This proceeds from an appearance of motes or flies passing before the eyes, and is occasioned by an affection of the retina, producing in it a sensation similar to that produced by the impression of images; and what is deficient in the sensation, the imagination supplies; for, although the resemblance betwixt those diseased affec-

* The following is an ingenious account of the manner in which this may be produced, though to me it is not satisfactory: — "Non infrequens cæcitas post convulsiones graves et frequentes, sed a nemine quod sciam recte descripta causa; hanc non ab humoris affluxu deduco, ut voluerunt, sed quia in magnis illis per paroxysmas convulsionum partium omnium, et oculorum simul contortionibus in quibus sæpe quoque convulsi, admodumque exerti et inflexi apparent, attracto sic nimium et tenso nervo optico, illis adnato illoque simul contorto et læso, spiritusque visorii transitu impedito, oculos visione privari contingit, atque inde provenire diligente examine et consideratione invenimus." *Platerus Prax.* lib. i. c. 7.

tions of the retina and the idea conveyed to the brain may be very remote, yet, by that slight resemblance, the idea usually associated with the sensation will be excited in the mind.

M. De la Hire attributed the fixed spots to drops of extravasated blood on the retina, and the flying ones to motes in the aqueous humours*; but we shall show presently, that this apparent motion of the motes before the eyes may be a deception. After turning round upon the heel for some time, objects apparently continue in motion. Dr. Porterfield supposed this to proceed from a mistake with respect to the eye, which, though it be at rest, we conceive to move the contrary way to that in which it moved before; from which mistake, with respect to the motion of the eye, the objects at rest will appear to move the same way the objects are imagined to move, and, consequently, will seem to continue their motion for some time after the eye is at rest. How superior is simple experiment to the most ingenious speculation! Dr. Porterfield is presuming in all this, that the eye is at rest when the body is stationary, after turning round rapidly on one foot. But the fact is, that the eyes continue in motion after the body is at rest, but, owing to a disorder in the system of sensation, we are not sensible of it. Dr. Wells, in making an experiment, in which it was necessary to look upon a luminous body, was seized with giddiness; and he found, that the spot on the retina, affected by the great excitement of the luminous body, did not remain stationary, but, when made apparent by looking upon the wall or any plane, was moved in a manner altogether different from what he conceived to be the direction of his eyes. In making the experiment, after looking some time at a candle, and then turning himself round till he became giddy, he afterwards directed his eyes to the middle of

* "Guttula cruoris retinæ insidens et nigricans, omnem lucem intercipiet unde phantasma obscurum vel nigrum; verum si dilutus cruor radios rubros transmittat tunc maculam rubram videbit æger ut omnia trans vitrum inspecta rubra sunt." *Sauvage*, vol. iv. p. 287.

a sheet of paper: he saw the dark spot (caused by the former brilliancy of the candle on the retina) take a course over the paper, although he conceived that the position of his eyes remained stationary. He then directed a person to repeat this experiment, and then bade him look stedfastly to him, and keep his eyes fixed; but, instead of being stationary, they were seen to move in the socket; though, of this the person himself was quite insensible.*

From these experiments we may conclude, that spots which seem to move before the eyes are not, on that account, solely to be attributed to opacity of the humours or cornea, since the appearance of motion may be given to those motes, though occasioned by an affection of the nerve; especially, if the unusual sensation be attended with giddiness. Giddiness, however, is not necessary to such sensation: when my eyes are fatigued, and, sitting in my room, I look towards the window, I see before me small lucid circles, which seem to descend in quick succession: upon attending more particularly to my eyes, I find them in perpetual motion; my eye is turned gradually downward, which gives to the spectrum the appearance of descending; but it regains its former elevation with quick and imperceptible motion. During the slow inclination of the eye downward, the motes or little rings seem to descend; but, in lifting the eye again, the motion is so quick, that they are not perceived.†

* The author has pursued this subject further, both in a succeeding part of the volume, and in the Phil. Transac. for 1829.

† The following quotation refers to this sensation:—"Æger in magnâ luce constitutus, ut plurimum presbyta, vel oculis nitidissimis gaudens continuo præ oculos observari sibi putat puncta lucida, quæ non huc et illuc volitant, nec a commoto capite agitantur, ut putat La Hire, et ejus in hoc exscriptor Boerhaave; sed constanter si oculus immobilis remaneat, deorsum lentissime delabi videntur; adeoque veluti pluvia aurea præ-oculos eaque densa cernitur; quæ verticaliter semper descendit in quacunque capitis positura, sive erecta, sive lateraliter inclinata; hoc in me ipso expertus per annos, observari in aliis, potissimum illos qui studio nocturno indulserant, et in ægrotante, qui de eo symptomate ad melancholiam fere per multos annos sollicitus erat." *Sauvages.* This appearance has been attempted to be

There is a kind of umbra seen before the eyes which are occasioned by the vessels of the retina. Of this kind is the suffusio reticularis of Sauvages, in which the person sees ramifications which strike across the sphere of vision, and are synchronous with the pulse, showing its dependence on the full and throbbing pulsation of the head. There are also coruscations seen before the eyes in consequence of a blow upon the eye-ball, and accompanying violent headache, vertigo, phrenitis, epilepsy, &c. Whatever forces the blood with great violence to the head, as coughing, vomiting, sneezing, will cause, for the instant, such coruscations, by means of the disturbed circulation through the retina.*

We are particularly called upon to attend to the connection betwixt the iris and the retina. In amaurosis, the sensibility of the retina being entirely lost, the pupil is consequently immovable and dilated.† But we must recollect, that if one eye be sound, the pupil of the diseased eye follows, in some degree, the movement of the iris of the sound eye. If one eye be shut, the pupil of the other eye will dilate; if the hand be put over the eye-lids of the shut eye, the pupil will still further dilate.‡

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explained, upon the supposition of a very sensible state of the retina, which perceives the guttulæ exuding from the pores of the cornea, and which, falling over its surface, gives the appearance of their descending. But it is only felt when the retina is exhausted or disturbed by pressure on the eye-ball. See *Sauvages Suffusio Scintillans et Suff. Danaës.*

* This was my opinion, as well as that of other physiologists; but I have proved it to be incorrect. The effect contemplated proceeds from the sudden action of the muscles of the eye-lids.

† There are, however, cases of AMAUROSIS A MYOSI, in which there is a contracted and immovable pupil, and children are born with an insensibility of the organ in which the pupil is not greatly dilated. I would be willing to attribute this peculiarity of the pupil and apparent amaurosis in newly-born children to the remains of the membrana pupillaris.

‡ The sympathy of the iris with the retina I do not conceive to be immediate, but through the intervention of the brain; and the degree of dilatation of the pupil I should hold to depend on the strength of

We find several instances of vision indistinct during full day-light, and perfect in the crepusculum. This we have explained by the dilatation of the pupil allowing the rays of light to pass the partial opacity of the lens: it, of course, has no connection with the disease of the retina.

There are also instances of vision being more than naturally obscure in the twilight, which is owing to a degree of insensibility.† The night-blindness, however, is not to be entirely attributed to a degree of continued insensibility in the nerve. The attacks are irregular, and allied to the intermitting amaurosis. It has been epidemic, and the following cases seem to ally it with the paralytic affections.‡

A man, about thirty years old, had, in the spring, a tertian fever, for which he took too small a quantity of bark, so that the returns of it were weakened without being entirely removed; he therefore went into the cold bath, and, after bathing twice, he felt no more of his fever. Three days after his last fit, being then employed on board of a ship in the river, he observed, at sun-setting, that all objects began to look blue, which blueness gradually thickened into a cloud, and not long after he became so blind as hardly to perceive the light of a candle. The next morning, about sun-rise, his sight was restored as perfectly as ever. When the next night came on, he lost his sight again in the same manner; and this continued for twelve days and nights. He

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the common sensation of both eyes. By this only can we account for the sensibility of the retina of one eye affecting the iris of the other, or the disturbance of the brain, in comatose diseases, destroying the sympathetic connection betwixt the retina and pupil.

† Est immanis differentia inter splendorem et activitatem luminis candelæ et lunæ: luminis solaris vis est ad vim luminis candelæ 16 pedis distantis, observante D. Bouguer ut 11,664 ad 1; et ad lumen lunæ in pleni lunio, ut 374,000 ad 1 demonstrante D. Euler, Mem. de l'Acad. de Berlin, an. 1750, pag. 290.; non mirum itaque si vis toties major sufficeret ad succutiendam retinam quam tanto minor non afficiebat. *Sauvages Amblyopia Crepuscularis.*

‡ By Dr. Heberden.

then came ashore, where the disorder of his eyes gradually abated, and in three days was entirely gone. A month after, he went on board of another ship, and, after three days' stay in it, the night-blindness returned as before, and lasted all the time of his remaining in the ship, which was nine nights. He then left the ship, and his blindness did not return while he was upon land. Some little time afterwards, he went into another ship, in which he continued ten days, during which time the blindness returned only two nights, and never afterwards.

In the August following, he complained of loss of appetite, weakness, shortness of breath, and a cough: he fell away very fast, had frequent shiverings, pains in his loins, dysury, and vomitings; all which complaints increased upon him till the middle of November, when he died. He had formerly been employed in lead-works, and had twice lost the use of his hands, as is usual among the workers in this metal. See Medical Transactions, published by the College of Physicians in London, vol. i. p. 60.

Pye *, servant to a miller, at the 6th mill on the Limehouse wall, about 40 years of age, came to me, October 2d, 1754, for advice and assistance. He told me, that about two months ago, while he was employed in mending some sacks, near the setting of the sun, he was suddenly deprived of *the use of his limbs* and of his sight. At the time he was attacked with this extraordinary disease, he was not only free from any pain in his head or his limbs, but, on the contrary, had a sensation of ease and pleasure: he was, as he expressed himself, as if in a pleasing dose; but perfectly sensible. He was immediately carried to bed, and watched till midnight; at which time he desired those who attended him to leave him, because he was neither sick nor in pain. He continued the whole night totally blind, and without a wink of sleep.

* Case by Dr. Samuel Pye.

When the day-light of the next morning appeared, his sight returned to him gradually, as the light of the sun increased, till it became as perfect as ever; when he rose from bed, his limbs were restored to their usual strength and usefulness, and himself in perfect health.

But on the evening of the same day, about the setting of the sun, he began to see but obscurely, and his sight gradually departed from him, and he became as blind as on the preceding night; though his limbs continued as well as in perfect health; nor had he, from the first night, any complaint from that quarter.

The next day, with the rising sun, his sight returned; and this has been the almost constant course of his disease for two months past. From the second night the symptoms preceding the darkness were, a slight pain over the eyes, and a noise in his head, which he compared to a squashing of water in his ears.

After near two months continuance of the disease, on September the 29th the patient was able to see all night; on the 30th September, October 1 and 2, he was again blind all night; on the 3d he was able to see; on the 4th he was blind till 12; on the 5th was blind. From this he had no return of his complaint till June 1755; from which time till the third of October, when I again saw him, he had three or four attacks; from the 3d till the 10th he had an attack every evening. — He had at this time a purging. I ordered him an electuary of bark and nutmeg, which succeeded in removing the blindness; but the diarrhœa continued wasting him. On the 20th, delirium came on; on the 21st he became deaf: he died on the 25th, after having suffered from fever, pain in his bowels, and continued diarrhœa; but the defect in his eyes never returned after the 10th. This man had clear bright eyes: when his sight failed him the pupils were enlarged about one third in diameter. Medical Facts and Enquiries, vol. i. p. 111. I could give other cases from my note-book, but these are sufficient.

Boerhaave gives us an example of imperfect vision from a discordance betwixt the contraction of the iris

and the excitement of the retina; so that the pupil did not dilate in the proportion to the decay of light.*

When inflammation extends within the eye, or when the retina is excited by sympathy with the ophthalmia of the outer membranes, it may happen that the patient is totally blind during the day, and yet sees on the approach of evening, because, from the sensibility of the retina, the pupil is absolutely shut, but as the light is diminished, the pupil is gradually relaxed, and the obscure light admitted, and this obscure light, from the irritable state of the retina, gives a vivid sensation incomprehensible to the by-standers. Our judgments of the strength of sensations are comparative merely: when we have been accustomed to strong impressions, lesser ones are disregarded. The greater light destroys the capacity of the retina for receiving slighter and more delicate impressions; while, on the other hand, the absence of light reserves to us the power of seeing objects the most faintly illuminated. We are every day becoming more acquainted with the invisible properties of light; and we have frequent experience of darkness being relative, and that which we should call total darkness is very often but a fainter light. One man will see distinctly when another is quite deprived of the power of discerning objects. A man in prison seems to have the light gradually admitted to him; and many animals are in quick pursuit of their prey, while we are groping our way with the assistance of our other senses.

Animals which seek their prey in a light which is darkness to us, have, most probably, a greater degree of sensibility of the retina. But they have also a more conspicuous apparatus in the largeness of their eyes, and the dilatability of their pupil, while the sensibility which this provision gives is often guarded from the light of day by the membrana nictitans, and by an iris capable of great contraction. Their iris possesses also a great power of contraction in narrowing the pupil during the

* In old people there is an obscurity of vision, from a diminished sensibility of the retina; and the iris does not take a quick succession of contraction and dilatation with the change of light.

day, as it is capable of dilating during the night, to the whole extent of the cornea. In the human eye, also, the strict sympathy between the iris and retina is a guard to the latter. But it has often happened that, in using optical instruments, the retina has been hurt by the intensity of the light from the concentrated rays: a lesser degree of this effect we have given us in the following instance *:—

"Being occupied in making an exact meridian, in order to observe the transit of Venus, I rashly directed to the sun, by my right eye, the cross hairs of a small telescope. I had often done the like in my younger days with impunity; but I suffered by it at last, which I mention as a warning to others. I soon observed a remarkable dimness in that eye, and for many weeks, when I was in the dark, or shut my eyes, there appeared before the right eye a lucid spot, which trembled much like the image of the sun seen by reflection from water. This appearance grew fainter and less frequent by degrees, so that now there are seldom any remains of it. But some other very sensible effects of this hurt still remain:—For, first, the sight of the right eye continues to be more dim than that of the left; secondly, the nearest limit of distinct vision is more remote in the right eye than in the other, although, before the time mentioned, they were equal in both these respects, as I had found by many trials; but, thirdly, what I chiefly intend to mention is, that a straight line in some circumstances appears to the right eye to have a curvature in it. Thus when I look upon a music-book, and, shutting my left eye, direct the right to a point of the middle line of the five which compose the staff of music, the middle line appears dim indeed at the point to which the eye is directed, but straight; at the same time the two lines above it and the two below it appear to be bent outwards, and to be more distinct from each other, and from the middle line, than at other parts of the staff to which the eye is not directed. Fourthly, although I have repeated this experiment times innumerable within these

* Viz. by Dr. Reid.

sixteen months, I do not find that custom and experience take away this appearance of curvature in straight lines. Lastly, this appearance of curvature is perceptible when I look with the right eye only, but not when I look with both eyes; yet I see better with both eyes together than even with the left eye alone."

Herschel, in making his observations on the sun, found the irritation to proceed from the red rays* (being those of the rays of light which have the property of producing heat in the greatest degree): he found, when he used red glass to intercept the too vivid impression of light on his eyes, that they stopped the light, but produced an insufferable irritation from the degree of heat. But when he used green glass it transmitted more light, and remedied the former inconvenience of an irritation arising from heat. He concluded that, in the darkening glasses for telescopes, the red light of the sun ought to be entirely intercepted. Boerhaave mentions an instance of the retina being injured by the long use of the telescope, and he himself was hurt by a similar cause. These injuries are owing to the intrusion of light highly concentrated, and over which the pupil has no command; it is a degree of intensity which the organ is not prepared to counteract.

OF THE MEMBRANA PUPILLARIS.

The membrana pupillaris is an extremely vascular membrane, which is extended across the pupil of the fœtus. It was discovered by Haller, Albinus, Wachendorf†, and Dr. William Hunter, at the same time, or without correspondence with each other.

Haller‡, after injecting, with oil of turpentine and cinnabar, a fœtus of the seventh month, saw through the cornea the vessels of the iris injected, and some

* See a curious instance of red colours producing convulsions in an epileptic patient. *Sandifort Thes.* vol. iii. pag. 314.

† In Commercio Norico, A. 1740, hebd. 18. as quoted by Haller.

‡ De novâ tunicâ pupillam fœtus claudente. Oper. minor.

ramifications from them produced into the space of the pupil. From conviction that no vessels ramified without an involving membrane, he naturally concluded, that a membrane was drawn across the pupil of the fœtus, though, in this instance, it was about to disappear.

In several other fœtuses of the seventh month he confirmed his first observation; and, cutting off the cornea, he observed the membrane impelled forward by the humours behind like a little vesicle.

Albinus, in his first book of Academical Annotations, thus describes the way in which he detected this membrane. In the same child, in whom he had filled the vessels of the crystalline lens, he also first observed the membrane which closes the pupil, and in which the vessels were injected that came from the margin of the pupil. Upon looking through the cornea, he could see no distinction of parts, but all seemed vascularity. He conceived, at first, that these were the vessels of the uvea, and that it had quite contracted, and had shut the pupil; then that they were the vessels of the capsule of the crystalline lens; but, having cut into the eye, he found it to be this membrane. Dr. Hunter, speaking of this membrane, and of Albinus's claim to the discovery, says, "In justice to this great anatomist, I must declare that I believe this, both because he asserts it, and because I know from the circumstances it was hardly possible he could miss taking notice of it in that child." "I have always observed," he continues, "both in the human body and in the quadruped, that there is a great resemblance to one another in the vessels of the capsula crystallini and of the membrana pupillæ. In an injected fœtus, I always find both nearly in the same state: if one be filled only with the blood that is drove before the injection, so is the other; if one be filled partly with injection, and partly with blood, the other is in the same condition; if one by good fortune be finely and minutely filled with injection, the other is so too; if one be burst by extravasation, the other is commonly in the same state; and when the fœtus is so

near its full time that the one cannot be injected, neither can the other."*

Dr. Hunter, speaking further of the artery of the crystalline capsule, says, "that it does not terminate at the great circle of that humour. Its small branches pass that circle, and run a very little way on the anterior surface of the crystalline humour before the points of the ciliary processes; then they leave the humour and run forwards, supported on a very delicate membrane, to lose themselves in the membrana pupillæ." He continues; "The membrana pupillæ receives two different sets of arteries, one larger, from the iris, and the other much smaller, but very numerous, from the crystalline capsule."

Now I think that every expression in these excerpts confirms the opinion I entertain, that these vessels which are seen filled with red blood, and which take their course through the humours, are subservient merely to the membrana pupillaris.

The first time I observed the membrana pupillaris, was in the eye of a child born at the full time. I had injected the child very minutely with size and vermilion, and the iris was beautifully red and the pupil quite transparent and black, and not obscured by any extravasation of the injection into the aqueous humour: upon very narrowly observing the circle of the iris, I saw distinctly a small injected vessel pass out from the edge of the iris, and, crossing the pupil, divide into two branches, which ran into the opposite margin of the iris. This was the remains of the membrane, but so delicate and so perfectly transparent, that the presence of it was only to be presumed from the vessel which was seen to cross the pupil.

Since that time I have often seen it in the early months, and particularly strong about the seventh month of the fœtus. It is then an opaque and very vascular membrane, and generally it has spots and streaks of extravasation in it. The vascular structure of this membrane is very particular, and I can assign no

* See Medical Commentaries, p. 63. foot-note.

other reason for this than that it may be a provision for its rapid absorption. It has evidently two sources of vessels, viz. the vessels of the capsules, and those of the iris; but whether the arteries come by the one source, and the veins depart by the other, I cannot determine. In one preparation I see the vessels with their trunk in the membrana pupillaris, and the branches sent over the surface of the iris.

The larger and flat venous-like vessels of the membrane are distributed in a beautiful net-work, in the form of the lozenge of a Gothic window. They have a free communication with each other. In their whole course the vessels seem nearly of the same size (which also is like the character of a venous net-work), and they terminate apparently in the margin of the iris.

Haller makes a comparison betwixt this membrane, which closes up the pupil, and that matter which is accumulated in the passage of the ear in the fœtus. But there is no analogy. — As the waters of the amnios might otherwise be in contact with the membrane of the drum of the ear, and injure what necessarily is of a dry and arid nature, this matter accumulated in the ear of the fœtus defends it. But at the time when the membrana pupillaris exists in its full strength and vascularity, no light is admitted into the eye — the fœtus is lying in the womb. Towards the ninth month, the membrane has become transparent, and, if not totally absorbed, it is torn by the first motion of the pupil, and altogether disappears. It can, therefore, have no effect in obscuring the light, and preventing it from exciting in too great a degree the eye of the newly-born child. I offer with some hesitation the following rationale: it is the nature of the iris to contract its circular fibres during the operation of light, so as to stretch the membrane, and to close or nearly close the pupil; that, on the other hand, the pupil is completely dilated through the operation of the radiated fibres of the iris in darkness: — To the question, then, why it is not dilated during the fœtal state? The answer, I think, may be this: — The iris is not loose in the fœtal state: it is connected and stretched to the middle degree of contraction and dilatation by the

membrana pupillaris. Were the iris in a full state of contraction during the life of the fœtus, it could not receive its full nourishment, proper degree of extension, and due powers; but, being preserved stationary and extended, the disposition to contraction, which it must have when the retina is without excitement, is counteracted, until it is about to receive, by the birth of the child, that degree of excitement which is to keep up the balance betwixt the two classes of fibres: those which dilate, and those which contract, the iris.

OF THE HUMOURS OF THE EYE.

OF THE AQUEOUS HUMOUR.

The aqueous humour is perfectly limpid. The use which I have assigned to the aqueous humour explains its nature and the extent of the chamber which contains it; viz. that it distends the cornea, and allows the free motion of the iris: it consequently fills the space between the lens and cornea. The usual description is, that it is lodged in two chambers: the one before the iris, called the anterior chamber of the aqueous humour; and the other behind the iris, called the posterior chamber of the aqueous humour.

This posterior chamber was, at one time, conceived to be of great extent *, and authors spoke of depressing the lens into the posterior chamber of the aqueous humour.† It is found, now, that betwixt the lens and iris there is no space to which we ought to give this name of chamber.

Heister, Morgagni, and M. Petit (médecin) first demonstrated the extreme smallness of the posterior chamber; and, after them, Winslow confirmed the fact, that the iris moved almost in contact with the anterior surface of the lens.

* Viz. by Heister. They were called the first and second chambers by M. Brisseau.

† There certainly appears sufficient room for this in Vesalius and Briggs' plates: these plates have misled many.

M. Petit gave the clearest proof of the smallness of the posterior chamber, by freezing all the humours of the eye, and dissecting them in their solid state. Without this expedient it was impossible to prove the relative size of the two chambers; for, whenever the cornea was cut, the aqueous fluid escaped, and the lens pushed forward. When the eye was frozen, and then dissected, it was found that the ice, which took the shape and dimensions of the anterior chamber, was much larger than that found in the posterior chamber*; indeed, the latter was formed of a very thin flake of ice. The thin piece of ice in the posterior chamber indicated as much fluid only betwixt the iris and lens as might allow a free motion to the iris. These experiments were instituted in the course of investigating the question of the nature of the cataract.

The conclusion, that the posterior chamber of the aqueous humour contained but one fourth of the whole aqueous humour, was admitted with great difficulty and after much contest. It determined the question, whether the cataract was a membrane or the opaque lens; for, as those who maintained that it was a membrane, said it could not be the lens, because the lens was far distant from the iris, it was necessary for their opponents to prove that the lens was close upon the pupil, and that the posterior chamber of the aqueous humour was very small.

It is agreed that, in the adult, the quantity of the aqueous humour amounts to five grains; in the fœtus it is red, turbid, and weighs about a grain and a half, owing, in part, to the comparatively greater thickness of the cornea.

As it is natural to conceive that the aqueous humour flows from a vascular surface, it is the most generally received opinion, that it is derived from the points of the ciliary processes and surface of the iris. Haller, particularly, and after him Zinn, have thought that the ciliary processes were the secreting bodies; but there is one argument, which, in my mind, determines that these are

* See Acad. Roy. des Sciences, 1723. Mem. p. 38.

not the sole secreting parts, viz. that while the membrana pupillaris closes up the communication betwixt the two chambers, I have observed the anterior one to be full of the fluid, which of course must have been supplied from another source than the ciliary processes. I suppose, therefore, that the villous surface of the iris is the proper secreting surface of the aqueous humour.* Zinn observes, that Haller saw the membrana pupillaris distended and bulged forwards by the aqueous humour in the posterior chamber. It is scarcely necessary to say, that this must always take place when the cornea is first opened in demonstrating that membrane, whether there be a watery fluid behind it or not. But I believe I shall be able to prove, that the secretion of the ciliary processes can have little power of filling the posterior chamber, even from the connection of membranes behind the membrana pupillaris in the fœtus. The aqueous fluid is perpetually undergoing the change of secretion and absorption, and this is the reason of its quick renewal when it has been allowed to escape by puncture of the cornea. The ancients were not ignorant of the quick regeneration of this fluid. It was proved to the moderns by a charlatan, Josephus Burrhus. Before the physicians of Amsterdam he punctured the cornea of a dog; then, instilling his liquor under the cornea, he bound up the eye: in a few days he took off the bandage, and showed them the cornea again distended with the aqueous humour. It was soon found that the instilled fluid was of no kind of consequence. Redi and Nuck made many experiments, and it was found that the aqueous humour was regenerated in the course of twenty-four hours. It is generated much more quickly than this.

When the disputes regarding the cataract ran high,

* The opinion of Nuck is now out of the question. He thought that he had discovered particular aqueducts, which conveyed the aqueous humours into the anterior part of the eye; but these are found to be nothing more than the short ciliary arteries which pierce the fore part of the sclerotica. M. Mery and Bonhomme (see Zinn. p. 143.) observed, in an adult, the pupil closed with the membrane; and, in this instance, there was scarcely any fluid in the anterior chamber, whilst the posterior was turgid with fluid.

and when to make new distinctions in the disease was taken as a mark of practical knowledge and of acuteness, there was a kind of cataract attributed to the aqueous humour. When the aqueous humour became turbid, white, and opaque, and obscured the pupil, they were absurd enough to call this a cataract. The turbid state of the aqueous humour is at once distinguishable from the opaque lens, because it obscures the iris as well as the pupil.

Pus is formed in the chambers of the aqueous humour, in consequence of deep inflammation, contusions, &c.; and from the same cause sometimes proceeds a bloody effusion. When the pus has lodged in the anterior chamber of the aqueous humour, it would appear, upon the authority of Galen, that an oculist of his day performed a cure by shaking the patient's head! * It is an operation of oculists to puncture and allow the pus to flow out, and some have even syringed out the pus with water †; but this must have been on the principles of Jos. Burrhus's exhibition; for the natural secretion is here the best diluent. When we recollect the nature of the parts with which the pus lies in contact, we cannot be sanguine in the hope of such an operation saving the eye. Sometimes there remains, after operation on the cornea, or in consequence of ulceration, a continued flow of the aqueous humour; the consequence is a subsiding of the cornea ‡: it becomes corrugated, opaque, and, from the contact of the iris, apt to adhere to the iris. In consequence of this suppuration, there sometimes follows an absolute obstruction of the pupil, from the coalescing and adhesion of the edges of the iris. §

* Mouchart says, he has often seen the oculist Woolhouse repeat this cure, by shaking his patient's head over the side of the bed. He attributed the cure to the falling of the pus into the posterior chamber, which, he supposes, has parts more capable of absorbing it.

† They were at variance regarding the place at which to puncture for this discharge:—Some did it behind the iris; there we know there is a crowd of vessels: the best place is the lower edge of the cornea before the iris. It seems to have been no uncommon accident, in this operation, to find the lens protruded through the pupil. The reason of this has been already explained.

‡ Rhytidosis, seu subsidentia et corrugatio corneæ.

§ Viz. Synizesis. There occasionally occurs congenital imperforation of the pupil.

THE VITREOUS HUMOUR.

The vitreous humour, as already explained, occupies almost entirely the great ball of the eye. It is consequently beyond the lens, and keeps it at the requisite distance, to cause the rays from objects to concentrate and impinge upon the retina. The vitreous humour is considerably denser than the aqueous humour.* Its involving membrane is called membrana hyoloides sive vitrea.† The peculiar appearance of this humour, its glairy-like consistence, is not owing to its density, but to the manner in which it is contained in its membranes. From being contained in a cellular structure of perfectly pellucid membranes, it has the adhesion and consistence of the white of an egg. This membranous structure of the vitreous humour has been demonstrated by acids and by freezing. When frozen, it was found to consist of pieces of ice connected by strong membranes, which separated with difficulty, and showed their torn fragments; and M. Demours lifted the transparent membranes with the point of a needle. Although the vitreous humour appears to be gelatinous it is not so in reality; and, when it is taken from the coats of the eye, it retains the shape for a time, but gradually subsides by the fluid exuding from the membranes, and this is accelerated by puncturing it.

OF THE CRYSTALLINE LENS.

The crystalline humour is a small body, of the shape of an optician's lens, of great power. It is of perfect transparency, and of density much greater than the vitreous humour. Its density to that of the vitreous humour is calculated to be as 1114 to 1016. But the crystalline is not of uniform density, for the centre forms a denser nucleus, surrounded by concentric layers, successively diminishing in density to the sur-

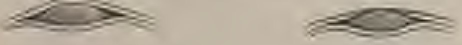
* It is, according to Dr. Monro, in the proportion of 1016 to 1000.
† Ophthalmographia, authore G. Briggs, 1676. Cantab.

face, where there is the liquor Morgagni surrounding the solid substance and contained within the capsule.

The form of the crystalline is that of a compressed sphere, the anterior surface being more compressed or flatter, though, in a degree, convex. According to Petit, the anterior surface is the segment of a sphere whose diameter is 7, 8, or even 9 lines. The posterior surface is a sphere of 4 or 5, or $5\frac{1}{2}$ lines in diameter. As I have said, the internal structure of the lens is quite peculiar, and resembles neither the vitreous nor the aqueous humour. By maceration it splits into lamellæ, and at the same time bursts up into equal parts, so that there is first a stellated-like fissure, and then it separates into pretty regular divisions. After maceration in acids, the lens can be frittered out into minute shreds and fibres.*

From its form, density, and central nucleus, it has great power of converging the rays of light; and, in an eye properly constituted, it concentrates them accurately to the surface of the retina. For this reason it is placed before the vitreous humour, and socketed in its anterior part. It is contained in a capsular membrane, the *tunica aranea* improperly called †, which membrane is continued from, or connected with, the membranes of the vitreous humour; but this is a subject which requires a more particular investigation.

OF THE CAPSULE OF THE LENS AND VITREOUS HUMOUR.



* See further of the muscularity of the lens.
† Ophthalmographia.

Here we have the appearance of the Petitian canal blown up; A is the lens, B the vitreous humour, C the Petitian canal. It is not found full of any fluid, it is only the laminæ of membrane inflated, and it is best demonstrated when the eye is slightly putrid by cutting off the cornea, and with it a small circular portion of the sclerotica, and taking with these the iris also, when the lens presents itself seated firmly in its capsule on the vitreous humour. Now, laying back the ciliary processes, we make a fine puncture with a lancet by the side of the lens, and then blow gently into it with the blow-pipe.

Every anatomist acknowledges the existence of the Petitian canal, and a distinct capsule to the lens is also pretty generally allowed. But many deny that the vitreous membrane has two plates, without observing that the existence of the Petitian canal is a proof of the splitting of the membrana vitrea, on the fore part at least. Some believe that the vitreous membrane splits and involves the lens, and forms its capsule; but the difficulty, on this supposition, is still to account for the formation of the canal which surrounds the lens; for, as the fluids on the surface of the lens and within its capsule have not admission to the canal, the canal must be distinct; and, indeed, sometimes we blow up the circular canal, and sometimes, by a wrong puncture, the capsule of the lens itself; but not both at once.

Seeing, then, that these cavities are distinct, some anatomists have admitted that the membrana vitrea is double; that the lens has its proper capsule; and that the lamina of the vitreous membrane, coming near the margin of the lens, splits and involves it in a second coat. Others have supposed the anterior layer of the vitreous humour does not pass over the anterior surface of the proper capsule of the lens, but only adheres to the edge of the capsule of the lens, and forms the Petitian canal. There are yet others who have described the membrana vasculosa of the retina, as forming the capsule of the lens. This is one of those species of anatomy which provokes us to continued research, and mortifies us with disappointment. If this piece of ana-

tomy, when investigated in the eye of an adult, is difficult to be understood, it is infinitely more complicated in the eye of the fœtus; and, for my own part, I cannot reconcile my experience with any former opinion.

I conceive that it is the membrana vasculosa tunicæ retinæ, or membrana vasculosa Ruyschii, which forms the vascular capsule of the lens in the fœtus, and also the canal of Petit in the adult. The crystalline lens has, in the first place, its proper capsule, which surrounds it on all sides: again, the transparent web of membrane that is continued onward from that part of the retina which has upon it the pulpy and nervous expansion, splits when it approaches the margin of the lens. One lamina goes round behind the lens, and the other passes a little before it, forms an adhesion to the capsule of the lens, and is then reflected off to the points of the ciliary processes and to the membrana pupillaris of the fœtus.* Betwixt these split laminæ of the continued membrane of the retina, the canal which surrounds the lens is formed. The membrana vitrea is simply reflected over the back of the lens, and has no part in forming the Petitian canal. Where the retina advances forward upon the ciliary processes, it forms an adhesion, beyond which the medullary part is not continued; but the membrana vasculosa passing onward, as I have described, embraces the lens, and the lamina, which passes behind the lens and before the vitreous humour, receives and conveys the artery of the capsule; on the fore part of the lens the anterior lamina only touches the capsule of the lens, adheres, and is then reflected off to form the membrana pupillaris.

In this account I am supported by the most careful investigation, and by the simplicity of this system of

* In the fœtus, as far as I have observed, the proper capsule of the lens and the membrana pupillaris lie in contact, but they do not adhere; and, while the membrana pupillaris is perfectly red with injection, there is none to be seen on the fore part of the capsule. There is, indeed, no part of that surface which is afterwards to secrete the aqueous humour, which could secrete that fluid, betwixt the surface of the lens and membrana pupillaris; so complete is the adhesion of the adventitious and vascular tunic of the lens to the membrana pupillaris.

vessels; for it will be observed, that it is on the membrana vasculosa alone, that the vessels carrying red blood in the fœtus are supported, and that it shows throughout the same character for vascularity. Again, I think it probable that this membrane which passes before the lens, viz. the membrana pupillaris, and that which passes behind the lens, forming the vascular capsule of the lens, disappear at the same time; or, if this posterior and vascular membrane which passes behind the lens is not totally absorbed, it becomes thin, loses its vessels, and is more intimately united to the membrana vitrea.

ACTION OF THE LENS ON THE RAYS OF LIGHT.

Before leaving this interesting subject, we must endeavour to show the application of these anatomical facts to the function of the lens. When we look upon a magnifying-glass, and see objects through it, we at the same time see the surfaces: that implies that the rays of light, striking these surfaces, are in part reflected, and in part refracted. But if we put the magnifying-glass into water, we no longer see the surfaces; and yet we see through the glass. The reason is this: when a ray of light passes from one medium into another, it has a disposition to reflection, in proportion to the difference of density; so that the ray passing through air is reflected from the surface of the glass: passing through water it is not reflected, but refracted, entering through the glass. In the same manner, if the surface of the lens had been exposed to air, or if the exterior surface of the lens had been as dense as its interior nucleus, we should have seen that surface on looking into the eye; that is to say, the rays of light would have been reflected in part, instead of all entering by refraction.

From such views we see why the lens consists of concentric layers, increasing in density inwards, and why its exterior surface is surrounded with the liquor Morgagni. We perceive also the advantage of the cornea being moistened; for the lacrymal secretion has the same influence on the light in entering the cornea that the

liquor Morgagni has on the rays entering the lens. The reader will perceive that this effect of the gradual succession of density is different from the effect attributed by Mr. Ramsden, and in addition to it. He observed that the *dispersion* of the refracted rays, producing the coloured rays, was to be observed only where there was a sudden density interposed in the course of the ray; and therefore that the gradual variation of the lens would prevent such dispersion.*

On the whole, therefore, we must conclude that this curious structure of the lens gives an image both more intense and truer in its colours than would be produced otherwise.

OF THE DISTRIBUTION OF THE CENTRAL ARTERY AND VEIN OF THE RETINA.

I am the more anxious to give the accurate distribution of these vessels, that Walter's account of them has tended much to derange that simple and natural view of this system which observation authorises us to take.

The arteria centralis retinæ arises from the ophthalmic artery.† Sometimes it is derived from the ciliary arteries before they enter the coats of the eye, and often there is more than one branch entering the optic nerve.‡ Arising from this source, there are many branches which are distributed to the retina, while a branch passes onward from the lamina cribrosa, through the vitreous humour, to the capsule of the lens. This vessel does not pass exactly in the centre of the vitreous humour, but to one side of the axis of the eye. When it arrives near the capsule of the lens, it divides into three or four

* It is affirmed by Dr. Young, on Experiments, that the dispersive power of the eye is one third of that of crown-glass. He suggests that this effect may be owing to the aqueous humour. *Trans. Roy. Soc.* for Nov. 1800.

† See Haller, Fascic. vii. tab. vi. fig. 2. 4. 7.

‡ Haller, F. vii. p. 42.

branches, which, reaching the capsule, spread beautifully on the back part of it.*

The BRANCHES of the arteria centralis retinæ, which are distributed in the retina, are subservient to its support, and are consequently as visible in the adult as in the fœtus; and, where the membrane of the retina has been described as adhering to the point of the ciliary body, these vessels of the retina unite to or inosculate with the vessels of the ciliary processes.

Walter objects to the description of the arteria centralis retinæ given by Haller and others: he says, decidedly, that there are no arteries distributed to the retina, and that anatomists have deceived themselves in supposing those vessels which ramify on the retina to be arteries, when, in reality, they are veins; he conceives, that the free return of the injection from the extremities of the arteries into the veins has misled them.

I am at a loss to conceive what notions Professor Walter can have entertained regarding this vein distributed in the retina, without an accompanying artery. It is a supposition contrary to the general frame of the economy, and I would oppose to it, with confidence, my own experience; since, in the ox and other animals, I have seen the veins of the retina turged with blood, and exceedingly distinct; yet, when I injected the trunk of the artery at the root of the optic nerve, I found a set of vessels injected on the surface of the retina quite different from the turgid veins, and which could be no other than the arteries distributed to the retina. I must conclude that there is no peculiarity in the distribution of vessels in the tunica vasculosa retinæ.

* Walter (de venis oculi) says, the arteria centralis retinæ, having perforated the membrana hyoloidea, passes through the middle of the vitreous humour, and scatters some twigs on the small cells of the vitreous humour. It does not, he says, run through the vitreous humour in a straight line from behind forward, nor does it divide into a great number of branches in the posterior part of the capsule of the lens, like radii from a centre, as Zinn has described. He asserts that the lens receives its vessels from the investiture of the membrana hyoloidea, and that they run back from the edge of the lens towards the posterior convexity.

We frequently observe that the trunks of veins and arteries, destined to the same final distribution, take a different course; but, in their final distribution, I know no instance in which they do not ramify with parallel branches interwoven with each other.

The VENA CENTRALIS RETINÆ, as it is described by Haller, is sometimes a branch of the ophthalmica cerebralis, but often it rises from the cavernous sinus, amongst the origins of the external and inferior recti muscles of the eye: after giving off many small twigs to the periosteum and fat of the orbit, it passes obliquely from behind, forward, and inward, perforates the sheath of the optic nerve, and, after supplying the sheath, dips into the surface of the nerve.—It is now the comes arteriæ centralis retinæ. It enters through the cribriform plate of the optic nerve, and spreading generally in large and remarkable branches on the retina, these make free inosculations with each other, and finally inosculate with the veins of the ciliary processes.

Whether a branch of the vena centralis retinæ is sent off to accompany the branch of the artery which takes its course through the vitreous humour, I have not been able to determine.

OF THE VASCULARITY OF THE PELLUCID MEMBRANES.

IF we cut through the sclerotic and choroid coat, round the optic nerve as it enters the eye, and afterwards cut up the outer coats towards the cornea, the humours fall out from these coats, and will remain suspended in a fluid, hanging by the optic nerve, and closely embraced by the retina: we have now to review these parts taken collectively, independent of the outward and proper coats, and, as I have classed them, as constituting the internal globe of the eye.

The first peculiarity which strikes us here is the perfect transparency of all the parts within the embrace of the retina. As there are, in the adult and healthy eye,

no vessels to be seen in the transparent membrane and humours, it becomes a question whether Nature has provided for the support and nourishment of those parts by other means than the common circulation of red blood through vessels? Now, I am inclined to think, that there is no such circulation through them; and I believe that this would be much more generally allowed, were there not something like a proof remaining in men's minds that these humours and tunics were supplied with red blood in the fœtus; whence they deduce the natural consequence that, in the adult state, these vessels are only shrunk so as to convey only colourless fluids. I have, therefore, to give my reasons why I think that these vessels of the fœtus are not subservient to the humours; and I think I shall prove that, when they have once disappeared, they are no longer pervious vessels; that, though those parts which they are supposed to supply should become inflamed and vascular in the adult, these vessels which were apparent in the fœtus do not become enlarged; that they do not administer in any way to inflammation and disease, but that a new source is given, and that vessels are formed which were at no former period discernible.

Why should there be red blood transmitted to the pellucid membranes and humours of the fœtus? Why is not that state of circulation, which nourishes and supports the parts in the adult state, sufficient for their growth and the progress to perfection which they undergo in the fœtus? Why is the capsule of the lens only crowded with vessels carrying red blood, while the proof of vessels passing to the cells of the vitreous coat stands upon some very rare and vague assertions, and such as can be naturally explained by the appearance of those vessels which merely pass through the vitreous humour for a different destination?

I believe this is a view which has been little attended to; but, upon the most minute enquiry, and upon examining the preparations of the vascularity of the eye of the fœtus, I can see no vessels passing into the humours and carrying red blood, which are not finally distributed to the membrana pupillaris. When we lay

open the eye of a fœtus, after a very minute and successful injection, we see vessels, which all proceed from the centre of the optic nerve, passing through the vitreous humour to the back of the capsule of the lens, viz. the branches of the arteria centralis retinæ. This artery divides very often into many branches before it arrives at the capsule of the lens: now, if these be filled with blood, or but partially injected, they have the appearance of being branches distributed to the vitreous humour, and not to the lens. This appearance is still more apt to deceive us when the lens is separated from the vitreous humour, and when the vitreous humour is otherwise disturbed, for then the vessels shrink and seem to terminate in the midst of the vitreous humour. When the injection is perfect there is no such appearance.

On the back of the lens we see a profusion of vessels; but I think I may positively say that these vessels do not penetrate to the lens itself, but are merely on the capsule, and that, having made the circuit of the lens, they terminate in the membrana pupillaris and ciliary body. I can observe no villi on the inner surface of the capsule of the lens, nor any appearance of its being a secreting surface, to lead me to suppose that these vessels secrete the lens, as Walter supposes they do; nor, after the most successful injection of the capsule of the lens and of the coats of the eye in general, can I observe the slightest stain of colour in the pellucid state of the lens, nor betwixt its white fibres when it becomes opaque. Nor have I observed, at any time, a single branch of these vessels, which are so profuse on the back of the lens, distributed to the anterior part of the capsule; on the contrary, they all terminate abruptly at that line, a little forward from the utmost verge of the lens, where they are united to the vessels of the membrana pupillaris and ciliary processes. Were these vessels of the capsule provided for the secretion of the lens, or were those vessels the trunks of lesser branches, which pierce into the substance of the lens, they would appear also on the fore part of the capsule.

If I am accurate in these observations, we are au-

thorised to deduce this conclusion: — that these vessels which we see running through the vitreous humour and capsule of the lens, and which are sometimes seen filled with red blood or injected with size and vermilion, are not the vessels of the humours, but vessels in their passage to the membrana pupillaris, and that they disappear totally when that membrane is absorbed. They are injected when the membrana pupillaris is injected: they are more difficult to fill when that membrane is becoming pellucid and tender towards the latter period of gestation; and with the annihilation of the membrane follows the disappearance of the vessels carrying red blood through the transparent humour of the eye.

In confirmation of the total annihilation of these central vessels of the vitreous humour, I have found that, when disease comes upon the lens of the adult, the vessels, which are apparent in consequence of inflammation, do not proceed through the old tract from the centre of the optic nerve and through the vitreous humour to the lens, but that they come from the extremity of the retina and laterally, and thence spread over the back of the lens.

An eye, which I had lately an opportunity of examining, confirmed me in this opinion. I assisted my brother in an operation on the eye, in which, the anterior part being diseased, it was cut away. I had soon an opportunity of retiring and examining the parts with Dr. Monro. I observed then an opaque spot on the posterior surface of the lens, which was indeed in the capsule, and to this spot there came vessels over the margin of the lens from the extremities of the vessels of the retina; but in the vitreous humour there were no vessels to be seen, nor any branches passing into the lens obliquely from behind, as they do in the fœtus.

SOME SURGICAL OBSERVATIONS CONNECTED WITH THE ANATOMY OF THE HUMOURS.

I HAVE already mentioned, as the principle of the operation of extracting the lens, that the simple action

of the muscles surrounding the eye-ball is sufficient to protrude the lens, if the incision of the cornea be of proper dimensions relative to the size of the lens. No doubt, if there have been thickening inflammation, and perhaps preternatural adhesions of the membranes surrounding the lens, the operation will necessarily become more complicated; the lens will not glide at once over the cheek when the incision of the cornea is completed. But, still, I think we are not to allow ourselves to consider it as a step of the operation, in any circumstances, that the ball of the eye is to be pressed; because, in that case, the membranes of the lens give way suddenly, and part of the vitreous humour unavoidably is protruded with it, or the edge of the lens is turned obliquely to the pupil, and the vitreous humour escapes by the side of it. It is better to destroy the adhesions with the instrument, and to scratch the capsule of the lens so that it may burst: whence it is evident that it is necessary, in order to insure the correct performance of the operation of extraction, that the lens should press equally forward on the pupil, and that the pupil should be allowed to dilate. From this it appears how loose the ideas of those are who can speak of trying first to couch, and, if that is not found to succeed, then to perform the operation of extraction. I conceive the attempt with the needle to preclude the operation of extracting, for these reasons: — An unsuccessful attempt to depress will, in general, be a laboured and reiterated motion of the point of the needle, which must occasion inflammation and an adhesion firmer than is natural. Again, in couching, the lens is removed from the axis of the eye so far only that, in the case of the extracting being attempted, it no longer equally opposes itself to the pupil, the consequence of which must be the escape of the vitreous humour and the detention of the lens.

In regard to the place at which the couching-needle is to be introduced, we may observe, that we are directed by the older surgeons to pierce the sclerotic coat very near to the edge of the cornea, because they were afraid of hurting the lens with the needle. The idea then en-

tertained was, that the cataract was a membrane hung behind the pupil and before the lens. The older surgeons had the idea that the needle entered before the lens, and passed at once into the aqueous humour. We are to disregard these injunctions of surgeons who directed the needle to be introduced with the idea of avoiding the lens; for, while their notions regarding the disease were erroneous, their rules of operating could not be correct: accordingly, we find them differing in their directions as to the place of piercing the cornea; some directing us to pierce it at the distance of one line from the edge of the cornea, others at the distance of four lines and a half.

Now that we know the place of the cataract, and know also that it is the opaque lens, we can be at no loss to introduce the needle correctly. If, says M. Petit, we pierce the sclerotic coat one line from the edge of the cornea, we pierce the tunica conjunctiva, sclerotica, choroid, vitreous humour, and ciliary processes before the needle enters the cataract. In this puncture, we wound the most vascular part, and, indeed, every delicate part of the eye; for even in this most anterior course the retina is equally lacerated with the others.* But if we pierce the sclerotic coat, three lines from the edge of the cornea, we avoid the ciliary ligament and body, and processes; and by directing it a little forward, in a line towards the opposite margin of the iris, we shall find the point of the needle advancing through the opaque lens; for, although the lens be so opaque as to prevent the light from striking the retina, it is so far transparent, in general, that the needle is distinctly seen entering its substance, and can be then directed, so as to transfix the cataract without hurting the iris.

We have seen that there is no posterior chamber of the aqueous humour fit to contain the depressed crys-

* In our most modern system of surgery, we are directed to enter the needle one tenth of an inch. To my certain knowledge, not only the ciliary body has been injured by this direction, but even the root of the iris has been seen to be pushed forward on the point of the needle.

talline lens. The belief, which even some modern surgeons have entertained, of the possibility of depressing the lens into the aqueous humour, is a remnant of those inaccurate notions respecting the size of the posterior chamber of the aqueous humour, and the place of the lens, which have long been corrected. With this, also, I think ought to have been forgotten, the idea of the rising of the lens after it has been depressed by the cataract floating in the humours.— The fact, I am confident, is this: when, after transfixing the cataract, we endeavour to dislodge it by depressing the point of the needle, we separate the adhesion between the humours and the points of the ciliary processes; we do not, however, unsocket the lens from the fore part of the vitreous humour, but, when the lens descends with the point of the needle from before the pupil, the vitreous humour revolves with it; the consequence of which is, that when the needle is withdrawn, the lens rolls round with the vitreous humour: but as the lens only is opaque, as its firm connection with the vitreous humour, and even the rolling of the vitreous humour itself cannot be seen, this rolling of the lens appears to be the consequence merely of its own buoyancy in the aqueous humour. This adhesion of the lens to the vitreous humour I have been sensible of during its depression, from the elastic nature of the resistance which I felt. When the lens parts from its socket in the vitreous humour, and when it is depressed with such a turn of the needle as puts it under the anterior part of the vitreous humour, it cannot rise again; there is no motion of the eye which can replace it; there is no aqueous fluid, in which, if it were of less specific gravity, it could rise: it lies under, and, in part, imbedded in the vitreous humour. Another idea is, that it rises with the needle; but no one, who understands what is to be done in the operation of the needle, will raise it again opposite to the pupil after the lens is depressed: it ought to be withdrawn without again elevating the point. But what has always appeared to me as the most unaccountable cause that can be assigned for the rising of the cataract is the

action of the muscles of the eye.* It has been explained how the lens is protruded by the action of the muscles when the cornea is cut and the aqueous humour let out; for then the uniform resistance of the eye is broken, and there is a motion of the humours towards the breach, and the lens, lying behind the pupil, is the first part to be protruded forward; but when it lies under the anterior part of the vitreous humour (and there it must lie if it is at all displaced), or in whatever situation it happens to be, from that it cannot be moved by the action of the recti muscles; for they embrace the eye on every side, and their action operates uniformly, so that they cannot affect a body immersed in the midst of the humours. For the same reason that we should decline the operation of extracting, after attempts have been made to depress with the needle, I should refuse when the pupil is rugged and irregular, because the disease may be more extensive than it appears to be. Thus cataracts brought on by falls, or blows, or punctures of the eye, are less favourable, as there is danger of the inflammation having gone deep, and having affected the other humours in a way which cannot be known, since the opaque lens is betwixt us and them.

A frequent cause of the failure of the operation of depression is the displacement of the lens backwards; for, when it seems to have gone down with the needle, it has slipped from under it and started backward. In this case the pupil appears clear, but the patient gains little advantage; for the cataract, though removed from the pupil, is still in the situation to obstruct the light.

OF THE EYELIDS, OF THEIR GLANDS, AND OF THE COURSE OF THE TEARS.

Having completed the description of the eye, as the organ of vision, we have now to attend to its connections, its adventitious membranes, the glands of the eyelids, and the course of the tears. It is plainly necessary

* See Mr. Benjamin Bell's *System of Surgery*.

that the eye should not be loose in the socket; but that in its rolling motion it should still be attached; and that, although the delicate anterior surface must be exposed, the internal parts of the socket should be defended from the intrusion of extraneous bodies. This is accomplished by the tunica conjunctiva.

The TUNICA CONJUNCTIVA, OF ADNATA, is the inflection of the common skin of the eye-lids. It goes a little back into the orbit, and is again reflected, so as to come forward and cover the fore part of the eye-ball. Here it is pellucid, and the white coat of the eye shines through it. It covers the cornea also; and here it is perfectly transparent, loses its character of vascularity, and is assimilated to the nature of the cornea. As this coat is a continuation of the common integuments, it is, like them, vascular and liable to inflammation. The tunica conjunctiva is the most common seat of ophthalmia. In the commencing inflammation we see the vessels turgid or blood-shot; by-and-by they elongate towards the surface of the cornea; the patient complains of dimness; the dimness becomes apparent to the surgeon; spots of opacity then form in the cornea; and the vessels of the conjunctiva are seen taking their course over the turbid surface of the cornea. In this stage of the inflammation, by cutting the turgid vessels of the conjunctiva, we interrupt the source of blood for a time, and procure a small evacuation; but these vessels soon coalesce again, and the flow of blood is renewed. A variety of appearances are produced by this process of inflammation, and these have appropriate names.

The TUNICA ALBUGINEA is the thin tendinous coat formed by the insertion of the recti muscles, which expand over the anterior part of the eye. I would admit this into the enumeration of the coats of the eye, merely to prevent confusion of names, and to make intelligible the descriptions of some of the older writers. It is not properly a coat. Where the conjunctiva covers the anterior part of the eye, the white sclerotic coat is seen under it; and, in consequence of this, the tunica conjunctiva is sometimes called albuginea.

A very material part of the structure of the eye still remains to be described — an apparatus by which the surface of the eye is preserved from injury, kept moist, and perfectly transparent.

The EYE-LIDS are composed of the common integuments, with this difference only, that they have a cartilaginous margin to give them shape, and muscular fibres, in the duplicature of their membrane, to give them motion. A small semilunar cartilage, which lies like a hoop in their edge, keeps them of a regular figure, and so as to close neatly over the eye. This cartilage having a triangular edge, and the base of the angle forming the flat surface of the margin of the eye-lid, they meet with the most perfect accuracy. Either end of this hoop-like cartilage is connected with the periosteum at the corners of the eye, so as to move with its fellow as upon a hinge. This cartilage of the eye-lid is called TARSUS.

The MEIBOMEAN GLANDS. — These are very elegant little glands which lie under the inner membrane of the eye-lids. About twenty or thirty ducts of these glands open upon the tarsus of each eye-lid. These ducts run up under the vascular membrane of the inside of the eye-lids; and minute glandular follicles, to the amount of about twenty, are attached to each of these ducts. These glands exude a white albuminous matter, which defends the edge of the eye-lid from the acrid tears, and closes them more accurately by its unctuosity. This matter is soluble in the tears.* The vascularity of the inner surface of the eye-lid is subservient to these glands; for the vessels forming their ramifications round the little glands secrete the matter into them. This is the seat of the ophthalmia tarsi; and, following this inflammation, the edges of the eye-lids, and the mouths of the ducts, are sometimes eroded with little ulcers. These ducts are the seat of the stye. This is an inflammation and closing up of the mouth of one of the ducts, which then swells up into a little hard granule in the edge of the eye-lid, accompanied with inflammation of its cyst or surrounding membrane.

* Majendie.

OF THE SECRETION AND COURSE OF THE TEARS.

The LACHRYMAL GLAND is seated in the upper and outer part of the orbit, and behind the superciliary ridge of the frontal bone. It is of a flattened form, and is depressed into a hollow of the bone. Several ducts from this gland open upon the inner surface of the upper eye-lid. By the reflection of the membrana conjunctiva from the eye-lid over the surface of the eye-ball, dust and motes are prevented from getting behind the eye-ball; and when they have got under the eye-lids, the extreme sensibility of the tunica conjunctiva excites the lachrymal gland, and the orbicular muscle of the eye-lids, (which, by its pressure, accelerates the flow of the tears,) and the dust or motes are washed out. The puncta for absorbing the tears and conveying them into the nose being at the inner angle or canthus of the eye-lids, we see the intention of the ducts of the lachrymal gland opening on the inside of the upper eye-lid towards the outer angle; for, by this means, the tears are spread over all the surface of the eye-ball, by the motion of the eye-lids, before they decline into the puncta. But the tears do not flow only when the gland is excited by dust; their secretion is perpetual, and, together with the motion of the eye-lids, they continually moisten the surface of the eye-ball. Even during sleep it is supposed they continue to flow: and here we may admire a provision for their conveyance towards the inner canthus, in the inclination of the tarsus to each other; for the eye-lids meet only on the outer edge of the broad surface formed by the tarsus, the consequence of which is, that a kind of gutter is left in the angle by the inner edges of the tarsus not meeting, which permits the tears from the ducts of the lachrymal gland to flow towards the puncta lachrymalia when the eye-lids are shut.

The PUNCTA LACHRYMALIA are the mouths of two ducts which form the beginning of a canal for drawing off the tears from the eye into the nose. These puncta are placed at the inner canthus of the eye, one on the

termination of the tarsus of the upper eye-lid near the nose, and the other at the corresponding extremity of the lower eye-lid: they are surrounded by a rigid substance; and their open mouths absorb by capillary attraction. These canals lead the tears into the lachrymal sac, and thence the tears pass into the nose.

The CARUNCULA LACHRYMALIS is that little body like the granulation of a wound which lies in the inner angle formed by the two eye-lids. Very small hairs are seen to sprout from it, and some small sebaceous follicles open upon its surface. Connected with the caruncula lachrymalis is the MEMBRANA OR VALVULA SEMILUNARIS. This is a fold or duplicature of the adnata, which appears like a distinct vascular membrane. It is drawn from under the caruncula lachrymalis, when the eye-ball is directed outward, so as then to appear like a web spread over the white of the eye near the inner canthus. By directing the eye towards the nose, this membrane is again accumulated about the caruncula. Of this more presently.

The LACHRYMAL SAC and DUCT lie in the os unguis or os lachrymale. This sacculus is a bag of an oblong or oval figure: it is sunk into the fossa of the os unguis, and defended by the frontal process of the superior maxillary bone; and it is covered by the ligamentous connection of the orbicularis muscle. This sac is the dilated upper end of the nasal duct; and into it the two canaliculi lachrymales (the extremities of which are the before-mentioned puncta) open as distinct tubes.

Two coats are described as forming the lachrymal sac: a nervous, white, external coat; and a vascular, pulpy, pituitary membrane. This sac, diminishing towards the lower part, and being received into the complete canal of the bone, becomes the nasal duct. Taking a course downward and backward, it opens into the nose under the inferior spongy bone. The lachrymal sac and duct are by some said to be muscular, which it is conceived is necessary to enable them to convey the tears into the nose; or, it may be, that they act like a syphon, the duct reaching down into the nose, being

like the long leg of the syphon, and drawing the tears in at the openings of the puncta.

The lachrymal sac and duct are very frequently diseased and obstructed. For example, after small-pox, syphilis, or in scrophulous constitutions, the inner membrane of the sac being of the nature of the pituitary membrane of the nose, inflames, swells, and adheres. The consequences of this are, first, a swelling of the lachrymal sac in the inner angle of the eye, and a watery or weeping eye: upon pressing the tumour, the tears, mixed with mucus, are forced back through the puncta; by-and-by the sac inflames and suppurates; matter is discharged by pressure of the sac; and, lastly, it is eroded and bursts out, discharging the tears and matter on the cheek. This is the complete character of the fistula lachrymalis. While the sac bursts outwardly, it often does further mischief within, by making carious the thin lamina of bone in which it lies.

MOTIONS OF THE EYE-BALL AND EYE-LIDS.

We do not reflect on those actions of our frame which are most admirable in themselves, which minister continually to our necessities, and perfect the exercise of our organs, until we be deprived of them: like unnatural children, unconscious or unmindful of indulgence, we feel only the loss of benefits. "With much compassion," says the religious philosopher, "as well as astonishment at the goodness of our loving Creator, have I considered the sad state of a certain gentleman, who, as to the rest, was in pretty good health, but only wanted the use of these two little muscles that serve to lift up the eye-lids, and so had almost lost the use of his sight, being forced, as long as this defect lasted, to shove up his eye-lids with his own hands!" *

Two objects are attained through the motion of the eye-ball. First, the control and direction of the eye to

* Paley's Natural Theology.

objects; secondly, the preservation of the organ itself, either by withdrawing the surface from injury, or by the removal of what is offensive to it. Without keeping this distinction before us, we shall not easily discover the uses of the parts.

There is a motion of the eye-ball which, from its rapidity, has escaped observation. At the instant in which the eye-lids are closed, the eye-ball makes a movement which raises the cornea under the upper eye-lid.

If we fix one eye upon an object, and close the other eye with the finger in such a manner as to feel the convexity of the cornea through the eye-lid, when we shut the eye that is open, we shall feel that the cornea of the other eye is instantly elevated; and that it thus rises and falls in sympathy with the eye that is closed and opened. This change of the position of the eye-ball takes place during the most rapid winking motions of the eye-lids. When a dog was deprived of the power of closing the eye-lids of one eye by the division of the nerve of the eye-lids, the eye did not cease to turn up when he was threatened, and when he winked with the eye-lids of the other side.

In patients deprived of the motion of the orbicularis palpebrarum by paralysis, we see every effort to close the eye-lids attended with a turning up of the eye-ball.

Nearly the same thing I observed in a girl whose eye-lids were attached to the surrounding skin, owing to a burn; for the fore part of the eye-ball being completely uncovered, when she would have winked, instead of the eye-lids descending, the eye-balls were turned up, and the cornea was moistened by coming into contact with the mouths of the lachrymal ducts.

The purpose of this rapid insensible motion of the eye-ball will be understood on observing the form of the eye-lids and the place of the lachrymal gland. The margins of the eye-lids are flat, and when they meet they touch only at their outer edges, so that when closed there is a gutter left between them and the cornea. If the eye-balls were to remain without motion, the margins of the eye-lids would meet in such a manner

on the surface of the cornea, that a certain portion would be left untouched, and the eye would have no power of clearing off what obscured the vision, at that principal part of the lucid cornea which is in the very axis of the eye; and if the tears flowed, they would be left accumulated on the centre of the cornea, and winking, instead of clearing the eye, would suffuse it. To avoid these effects, and to sweep and clear the surface of the cornea, at the same time that the eye-lids are closed, the eye-ball revolves, and the cornea is rapidly elevated under the eye-lid.

Another effect of this motion of the eye-ball is to procure the discharge from the lachrymal ducts; for by the simultaneous ascent of the cornea, and the descent of the upper eye-lid, the membrane on which the ducts open is stretched, and the effect is like the elongation of the nipple, facilitating the discharge of tears.

By the double motion, the descent of the eye-lid, and the ascent of the cornea at the same time, the rapidity with which the eye escapes from injury is increased. Even creatures which have imperfect eye-lids, as fishes, by possessing this rapid revolving motion of the eye, avoid injury and clear off impurities.

I may observe in passing, that there is a provision for the preservation of the eye, in the manner in which the eye-lids close, which has not been noticed; while the upper eye-lid falls, the lower eye-lid is moved towards the nose. This is a part of that curious provision for collecting offensive particles towards the inner corner of the eye. If the edges of the eye-lids be marked with black spots, it will be seen that, when the eye-lids are opened and closed, the spot on the upper eye-lid will descend and rise perpendicularly, while the spot on the lower eye-lid will play horizontally like a shuttle.

To comprehend certain actions of the muscles of the eye, we must remember that the caruncle and membrane called *semilunaris*, seated in the inner corner of the eye, are for ridding the eye of extraneous matter, and are, in fact, for the same purpose with that apparatus which is more perfect and appropriate in beasts and birds.

In quadrupeds there is a gland for secreting a glutinous and adhesive fluid, which is seated on that side of the orbit next the nose: it is quite distinct from the lachrymal gland; it is squeezed by an apparatus of muscles, and the fluid exudes upon the surface of the third eye-lid. This third eye-lid is a very peculiar part of the apparatus of preservation. It is a thin cartilage, the posterior part of which is attached to an elastic body. This body is lodged in a division or depression of the orbit on the side towards the nose. When the eye is excited, the eye-ball is made to press on the elastic body, and force it out of its recess or socket: the consequence of which is the protrusion of the cartilaginous third eye-lid, or *haw*, as it is termed in the horse. By this mechanism, the third eye-lid is made to sweep rapidly over the surface of the cornea, and, by means of the glutinous fluid with which its surface is bedewed, it attaches and clears away offensive particles.

In birds, the eye is an exquisitely fine organ, and still more curiously, and, as we might be tempted to say, artificially protected. The third eye-lid is more perfect: it is membranous and broad, and is drawn over the surface of the eye by means of two muscles which are attached to the back part of the eye-ball, and by a long round tendon, that makes a course of nearly three parts of the circumference of the ball. The lachrymal gland is small, and seated low, but the mucous gland is of great size, and seated in a cavity deep and large, and on the inside of the orbit. As the third eye-lid is moved by an apparatus which cannot squeeze the mucous gland at the same time that the eye-lid is moved, as in quadrupeds, the oblique muscles are particularly provided to draw the eye-ball against the gland, and to force out the mucus on the surface of the third eye-lid. It flows very copiously; and this is probably the reason of the smallness of the proper lachrymal gland which lies on the opposite side of the orbit.

We already see two objects attained through the motion of these parts: the moistening the eye with the clear fluid of the lachrymal gland; and the extraction, or rather the protrusion, of offensive particles.

There is another division of this subject no less curious: the different conditions of the eye, during the waking and sleeping state, remain to be considered. If we approach a person in disturbed sleep, when the eye-lids are a little apart, we shall not see the pupil nor the dark part of the eye, as we should were he awake, for the cornea is turned upwards under the upper eye-lid. If a person be fainting, as insensibility comes over him the eyes cease to have speculation; that is, they want direction, and are vacant, and presently the white part of the eye is disclosed by the revolving of the eye-ball upwards. So it is on the approach of death; for, although the eye-lids be open, the pupils are in part hid, being turned up with a seeming agony, which is the mark of increasing insensibility.

It will now be admitted, that the variety of motions to which the eye is subjected require the complication of muscles which we find in the orbit; and it must be obvious to the most casual observer, that unless these various offices and different conditions of the eye be considered, it will be in vain to attempt an accurate classification of the muscles of the orbit.

OF THE ACTIONS OF THE MUSCLES OF THE EYE, AND THEIR NATURAL CLASSIFICATION.

The muscles attached to the eye-ball are in two classes, the recti and obliqui. The recti muscles are four in number, and come from the bottom of the orbit, and run a straight course forwards and outwards: they embrace the eye-ball, and are inserted at four cardinal points into it. The obliqui are two muscles having a direction backwards and outwards *: they embrace the eye-ball, one passing over it obliquely, the other under it obliquely.

* We may say so; for, although the superior oblique muscle comes from the back of the orbit, yet, by passing through the trochlea, it has a course backwards and outwards to its insertion.

The muscles of the eye seen in front.

A. B. C. D. The recti muscles; voluntary muscles.
E. The superior oblique muscle or trochlearis.
a. The trochlea cut off from the bone and left attached to the tendon. It is a loop through which the tendon runs.
b. The tendon of the trochlearis muscle, expanding and running to its insertion.
G. The inferior oblique muscle. It is seen, like the tendon of the superior oblique, to run backwards and outwards.

That the recti muscles perform the office of directing the axis of the eye, turning it round to every point in the sphere of vision, there are many proofs. In the first place, their origin, course, and insertion, accurately fit them for this office; and they are obviously equal to it, unassisted by other muscles. In the next place, from man down to the cuttle-fish, the voluntary motions of the eyes are the same, and the origin, course, and insertion of these muscles are similar, while the other muscles vary with the change of apparatus which is around the eye.

The muscles of the eye seen in profile.

A. B. C. D. Three of the recti muscles. They arise together from the periosteum of the bottom of the orbit, and are inserted into the anterior part of the sclerotic coat of the eye.
E. The superior oblique muscle, or trochlearis.

a. The trochlea.
b. The reflected tendon inserted into the back and outer part of the sclerotic coat.
G. the inferior oblique muscle.
c. Its origin from the anterior part of the orbit.
d. Its insertion into the back and outer part of the eye-ball.

The oblique muscles of the eye stand contrasted with the recti in every respect; in number, size, and direction. Yet it is a received opinion, that they antagonise the recti, and keep the eye suspended. To this opinion there are many objections. 1. In creatures where the eye is socketed on a cup of cartilage, and cannot retract, the oblique muscles are nevertheless present. 2. Where a powerful retractor muscle is bestowed in addition to the recti muscles, the oblique muscles have no additional magnitude given to them. 3. In matter of fact, the human eye cannot be retracted by the united action of the recti, as we see quadrupeds draw in their eyes, which is an argument against these muscles being retractors, and therefore against the obliqui being their opponents, to draw it forward.

By dissection and experiment it can be proved, that the oblique muscles are antagonists to each other, and that they roll the eye in opposite directions, the superior oblique directing the pupil downwards and outwards, and the inferior oblique directing it upwards and inwards. But it is proved that any two of the recti muscles are equal to the direction of the pupil in the diagonal between them; and there is no reason why an additional muscle should be given, to direct the pupil upwards and inwards more than upwards and outwards, or downwards and inwards. It is evident, then, that the oblique muscles are not for assisting the recti in directing the eye to objects, but that they must have some other appropriate office. If we proceed farther, it must be by experiment.

To these, other objections, no less strong, may be added. We have just found that certain very rapid motions are to be performed by the eye-ball: now it can be demonstrated, that a body will be moved in less time by a muscle which is oblique to the line of motion, than if it lay in the line on which the body moves. If the

oblique muscles were either opponents or coadjutors of the recti, there appears no reason why they should be oblique, but the contrary; for as the points of their insertion must move more rapidly than those of the recti, they are unsuitable. On the other hand, that there may be no difference in the time of the action and relaxation of the several classes, we see a reason why one rectus should be opposed by another, and why, there being occasion for one oblique, its antagonist should also be oblique.

In proportion as a muscle gains velocity by its obliquity, it loses power; from the obliquity, therefore, of these muscles believed to be opposed to the recti, and from their being two of them to four of the latter, they are disproportioned in strength, and the disproportion proves that the two classes of muscles are not antagonists.

EXPERIMENTAL ENQUIRY INTO THE ACTION OF THESE MUSCLES.

I. I divided the *superior rectus* or *attollens* in a rabbit, and felt something like disappointment on observing the eye remain stationary. Shortly afterwards, on looking to the animal while it was feeding, I saw the pupil depressed, and that the animal had no power of raising it.

The explanation I conceive to be this: during the experiment the eye was spasmodically fixed by the general action of the muscles, and particularly by the powerful retractor, a muscle peculiar to quadrupeds. But on the spasm relaxing, and when the eye was restored to the influence of the voluntary muscles, the recti, the voluntary power of raising the eye being lost by the division of the superior muscle, the eye was permanently depressed.

II. Wishing to ascertain if the oblique muscles contract to force the eye-ball laterally towards the nose, I put a fine thread round the tendon of the superior oblique muscle of a rabbit, and appended a glass bead to it of a weight to draw out the tendon a little. On

touching the eye with a feather, I had the pleasure of seeing the bead drawn up. And, on repeating the experiment, the thread was forcibly drawn through my fingers.

By experiments made carefully in the dead body (having distended the eye-ball by dropping mercury into it to give it its full globular figure), I had found that the action of the superior oblique muscle is to turn the pupil downwards and outwards, and that the inferior oblique just reverses this motion of the eye. In the above experiment there is abundance of proof that the superior oblique muscle acted, and yet the pupil was not turned downwards and outwards, therefore both oblique muscles must have been in action. Their combined action draws the eye-ball towards the nose.

In the violent spasmodic affection of the eye, when it is painfully irritated, I believe that all the muscles, both of the eye-ball and eye-lids, are excited. In quadrupeds, I have ascertained that the oblique muscles act when the haw is protruded; but I have also found, that the retractor oculi alone is capable of forcing forwards the haw.

But quadrupeds, having an additional apparatus of muscles to those of the human eye, are not suited for experiments intended to illustrate the motions of our eyes. The monkey has the same muscles of the eye with man.

III. I cut across the tendon of the superior oblique muscle of the right eye of a monkey. He was very little disturbed by this experiment, and turned round his eyes with his characteristic enquiring looks, as if nothing had happened to affect the eye.

IV. I divided the lower oblique muscle of the eye of a monkey. The eye was not, in any sensible manner, affected: the voluntary motions were perfect after the operation.

V. On holding open the eyes of the monkey, which had the superior oblique muscle of the right eye divided,

and waving the hand before him, the right eye turned upwards and inwards, while the other eye had a scarcely perceptible motion in the same direction. When the right eye was thus turned up, he seemed to have a difficulty in bringing it down again.

From experiments it is proved, that the division of the oblique muscles does not in any degree affect the voluntary motions by which the eye is directed to objects.

This cannot, however, be said of the involuntary winking motions of the eyes. We have seen that in winking to avoid injury, the oblique muscles were in operation; and that the inferior oblique muscle gained in the power of elevating the eye-ball by the division of the superior oblique, its opponent.

These revolving motions, accompanying the winking motions of the eye-lids, are of the utmost consequence to the preservation of the organ. A case which was some time under my observation proved this. By a defect of motion, the eye and eye-lids remained fixed, and the consequence was that the cornea inflamed and became opaque. Another curious circumstance in this case was, that when the eye-lids were closed, the patient still saw red light through the affected eye, the reason of which was that the eye-ball did not turn up when the eye-lid was closed.

If we close the eyes opposite to the window or before a candle, and continue to attend to the sensations of the eye, we shall still see red light coming through the eye-lids. But if we make an effort to close the eye-lids (though they be already shut), we shall be in momentary darkness, because during the effort the eye-balls are then turned up. Thus it appears that the dropping of the eye-lid would make but an imperfect curtain before the eye, and the eye, to be entirely protected from the light, must have the pupil turned upwards.*

* In the case above alluded to, the patient had lost both motion and the common sensibility of the eye; the office of the fifth nerve was lost, yet the optic nerve retained its power, and he could see.

ON THE TWO CONDITIONS OF THE EYE, ITS STATE OF REST, AND OF ACTIVITY.

The eye is subject to two conditions: a state of rest, with entire oblivion of sensation; and a state of watchfulness, during which both the optic nerve and the nerve of voluntary motion are in activity. When the eye is at rest, as in sleep, or even when the eye-lids are shut, the sensation on the retina being then neglected, the voluntary muscles resign their office, and the involuntary muscles draw the pupil under the upper eyelid. This is the condition of the organ during perfect repose.

On the other hand, there is an inseparable connection between the exercise of the sense of vision and the exercise of the voluntary muscles of the eye. When an object is seen, we enjoy two senses: there is an impression upon the retina; but we receive also the idea of position or relation, which it is not the office of the retina to give. It is by the consciousness of the degree of effort put upon the voluntary muscles, that we know the relative position of an object to ourselves. The relation existing between the office of the retina and of the voluntary muscles may be illustrated in this manner.

Let the eyes be fixed upon an illuminated object until the retina be fatigued, and in some measure exhausted by the image; then, closing the eyes, the figure of the object will continue present to them: and it is quite clear that nothing can change the place of this impression on the retina. But, notwithstanding that the impression on the retina cannot be changed, the idea thence arising may. For, by an exertion of the voluntary muscles of the eye-ball, the body seen will appear to change its place; and it will, to our feeling, assume different positions, according to the muscle which is exercised. If we raise the pupil, we shall see the body elevated; or, if we depress the pupil, we shall see the body placed below us: and all this takes place while the eye-lids are shut, and when no new impression is conveyed to the retina. The state of the retina is here associated with a consciousness of muscular exertion;

and it shows that vision in its extended sense is a compound operation, the idea of position of an object having relation to the activity of the muscles.

We may also show, by varying this experiment, that an agitated state of the muscles, or a state of action where the muscles are at variance or confused, affects the idea of the image. If we look on the luminous body so as to make this impression on the retina, and then cover the face so as to exclude the light, keeping the eye-lids open, and if we now squint, or distort the eyes, the image which was vividly impressed upon the retina instantly disappears as if it were wiped out. Does not this circumstance take place, because the condition of the muscles thus unnaturally produced, being incongruous with the exercise of the retina, disturbs its operation?

If we move the eye by the voluntary muscles, while this impression continues on the retina, we shall have the notion of place or relation raised in the mind; but if the motion of the eye-ball be produced by any other cause, by the involuntary muscles, or by pressure from without, we shall have no corresponding change of sensation.

If we make the impression on the retina in the manner described, and shut the eyes, the image will not be elevated, although the pupils be actually raised, as it is their condition to be when the eyes are shut, because there is here no sense of voluntary exertion. If we sit at some distance from a lamp which has a cover of ground-glass, and then fix the eye on the centre of it, and then shut the eye and contemplate the phantom in the eye; and if, while the image continues to be present of a fine blue colour, we press the eye aside with the finger, we shall not move that phantom or image, although the circle of light produced by the pressure of the finger against the eye-ball moves with the motion of the finger.

May not this be accounted for in this manner? the motion produced in the eye-ball not being performed by the appropriate organs, the voluntary muscles, it conveys no sensation of change to the sensorium, and is

not associated with the impression on the retina, so as to affect the idea excited in the mind. It is owing to the same cause that, when looking on the lamp, by pressing one eye, we can make two images, and we can make the one move over the other. But, if we have received the impression on the retina so as to leave the phantom visible when the eye-lids are shut, we cannot, by pressing one eye, produce any such effect. We cannot, by any degree of pressure, make that image appear to move, but the instant that the eye moves by its voluntary muscles, the image changes its place; that is, we produce the two sensations necessary to raise this idea in the mind: we have the sensation on the retina combined with the consciousness or sensation of muscular activity.

These experiments, and this explanation of the effect of the associated action of the voluntary muscles of the eye-ball, appear to me to remove an obscurity in which this subject has been left by the latest writers. In a most scientific account of the eye and of optics, lately published by Dr. Brewster, it is said on this question, "We know nothing more than that the mind residing, as it were, in every point of the retina, refers the impression made upon it, at each point, to a direction coinciding with the last portion of the ray which conveys the impression." The same author says, "Kepler justly ascribed erect vision from an inverted image to an operation of the mind, by which it traces the rays back to the pupil, and thus refers the lower part of the image to the upper side of the eye." What can be here meant by the mind following back the ray through the humours of the eye? It might as well follow the ray out of the eye. A greater authority says, we puzzle ourselves without necessity.—"We call that the lower end of an object which is next the ground." No one can doubt that the obscurity here is because the author has not given himself room to illustrate the subject by his known ingenuity and profoundness. But it appears to me, that the utmost ingenuity will be at a loss to devise an explanation of that power by which the eye becomes acquainted with the position and relation of

objects, if the sense of muscular activity be excluded, which accompanies the motion of the eye-ball.

Let us consider how minute and delicate the sense of muscular motion is by which we balance the body, and by which we judge of the position of the limbs, whether during activity or rest. Let us consider how imperfect the sense of touch would be, and how little of what is actually known through the double office of muscles and nerves would be attained by the nerve of touch alone, and we shall be prepared to give more importance to the recti muscles of the eye, in aid of the sense of vision;—to the offices performed by the frame around the eye-ball in aid of the instrument itself.

OF THE EXPRESSION OF THE EYE, AND OF THE ACTIONS OF THE OBLIQUE MUSCLES IN DISEASE.

During sleep, in oppression of the brain, in faintness, in debility after fever, in hydrocephalus, and on the approach of death, the pupils of the eyes are elevated. If we open the eye-lids of a person during sleep or insensibility, the pupils will be found elevated. Whatever be the cause of this, it will be found that it is also the cause of the expression in sickness, and pain, and exhaustion, whether of body or mind; for then the eye-lids are relaxed and fallen, and the pupils elevated so as to be half covered by the upper eye-lid. This condition of the eye, during its insensible unexercised state, we are required to explain.

It is a fact familiar to pathologists, that when debility arises from affection of the brain, the influence is greatest on those muscles which are, in their natural condition, most under the command of the will. We may perceive this in the progressive stages of debility in the drunkard, when successively the muscles of the tongue, the eyes, the face, the limbs, become unmanageable; and, under the same circumstances, the muscles which have a double office, as those of the chest, lose their voluntary motions, and retain their involuntary motions,

the force of the arms is gone long before the action of breathing is affected.

If we transfer this principle, and apply it to the muscles of the eye, we shall have an easy solution of the phenomena above enumerated. The recti are voluntary muscles, and they suffer debility before the oblique muscles are touched by the same condition; and the oblique muscles prevailing, roll the eye.

If it be farther asked, Why does the eye roll upwards and inwards? We have to recollect, that this is the natural condition of the eye, its position when the eye-lids are shut and the light excluded, and the recti at rest and the obliqui balanced.

Although I am aware that medical histories do not often lead to the improvement of strict science, yet I am tempted to describe the condition of a patient now under my care, because it exhibits a succession of those phenomena which we seek to explain. He presented himself to me in the hospital with a distinct squint, the left eye being distorted from the object. On the eye-lid of the right eye there was a deep venereal ulcer; the man was in danger of losing the right eye, and required prompt assistance; but, before he could be brought under the influence of mercury, the inflamed sore became deeper and the cornea opaque. The superior rectus muscle being, as I suppose, injured by the increasing depth of the sore, the pupil became permanently depressed. The sight of the right eye being now lost, the left eye came into use: it was directed with precision to objects; he had no difficulty in using it, and it daily became stronger.

After a few weeks, medicine having had its influence, the sore on the upper eye-lid of the right eye healed, the inflammation and opacity of the eye gradually diminished, the light became again visible to him: first it was yellow, and then a deep purple. And now the muscles resumed their influence, and the eye was restored to parallel motion with the other, and so as considerably to embarrass the vision. But the inflammation of the upper eye-lid had been so great as to diminish its mobility; and, what appeared most extraordinary,

the lower eye-lid assumed the office of the upper one, and a very unusual degree of motion was remarked in it. It was depressed when he attempted to open the eye, and elevated and drawn towards the nose, when he closed the eye. But the upper eye-lid was not only stiff, but diminished in breadth; so that, notwithstanding the remarkable elevation of the lower eye-lid, their margins could not be brought together, and we could perceive the motion of the eye-ball: in his attempt to close the eye we constantly saw the pupil elevated, and the white part of the eye exposed.

I shall now attempt the explanation of these phenomena.

The impression upon the left eye had been weak from infancy and the retina being unexercised, the recti, or voluntary muscles, wanted their excitement, and were deficient in activity; the involuntary muscles therefore prevailed, and the pupil was turned upwards and inwards, and consequently removed from the axis of the other eye. But when that other eye became obscured, the left eye being the only inlet to sensation, the attention became directed to the impression on the retina, the voluntary muscles were excited to activity, and they brought the eye to bear upon objects. This eye improved daily, because the natural exercise of a part is its stimulus to perfection, both in function and in growth. When the right eye became transparent, and the light was admitted, the voluntary muscles of that eye partook of their natural stimulus, and commenced that effort in search of the object, which in the course of a few days brought the eye to its proper axis, and both eyes to parallelism.

The next thing that attracts our attention in this short narrative is the revolving of the eye-ball. It has been explained in a former part of the paper, that when the eye-lids are shut, the recti, or voluntary muscles, resign their office, and the inferior oblique muscle gains power, and the eye-ball traverses so as to raise the pupil. It will not have escaped observation, that the pupil of this eye was depressed, and could not be elevated by a voluntary act for the purpose of vision, owing, as we have

supposed, to the injury of the rectus attollens, at the same time that it was thus raised involuntarily, in the attempt to shut the eye—a proof that this insensible motion is performed by the lower oblique muscle, and not the superior rectus muscle.

The circumstance of the lower eye-lid assuming the functions of the upper one, and moving like the lower eye-lid of a bird, reminds me of an omission in the account of authors. They have sought for a depressor of the inferior eye-lid, which has no existence, and is quite unnecessary; for the motion of the *M. elevator palpebræ superioris* opens wide the eye-lids, and depresses the lower eye-lid, at the same time that it elevates the upper eye-lid. If we put the finger on the lower eye-lid when the eye is shut, and then open the eye, we shall feel that during this action the eye-ball is pushed outwards; and we may observe, that the lower eye-lid is so adapted as to slip off the convex surface of the ball, and is consequently depressed. The reason of this is, that the muscle which raises the upper eye-lid passes over a considerable part of the upper and back part of the eye-ball; and the origin and insertion of the muscle being under the highest convexity of the ball, that body must be pressed forwards in proportion to the resistance of the upper eye-lid to rise. In the preceding case, the upper eye-lid being stiff and unyielding, both the origin and insertion of the *elevator palpebræ* became fixed points; consequently, the action of the muscle fell entirely on the eye-ball itself, whereby it was forced downwards and forwards in an unusual manner, and so depressed the lower eye-lid to an unusual degree. Thus the muscle became a *depressor* of the inferior eye-lid, instead of an *elevator* of the upper eye-lid! The motion of elevation in the lower eye-lid was of course performed by an increased action of the lower portion of the *orbicularis palpebrarum*.

But it has been observed, that the shutting of the eye-lids is not the only part of the act of preservation, and that the motions of the eye-lids are attended with a rolling of the eye-ball. How is this relation between the eye-lids and eye-ball established? This leads to an ex-

amination of the fourth nerve, which could not be done before.

THE FOURTH NERVE.

We have seen that it takes its origin from the brain, at a part remote from all the other nerves which run into the orbit. It threads the intricacies of the other nerves without touching them, and is entirely given to one muscle, the superior oblique. We may observe, too, that this singularity prevails in all animals. What office can this nerve have in reference to this one muscle? Why is its root, or source, different from the other nerves, — from the nerve of vision, the nerve of common sensibility, and the nerve of voluntary motion? We now reflect, with increased interest, on the offices of the oblique muscles of the eye, observing that they perform an insensible rolling of the eye-ball, and hold it in a state of suspension between them. We have seen that the effect of dividing the superior oblique was to cause the eye to roll more forcibly upwards; and if we suppose that the influence of the fourth nerve is, on certain occasions, to cause a relaxation of the muscle to which it goes, the eye-ball must be then rolled upwards.*

* The nerves have been considered so generally as instruments for stimulating the muscles, without thought of their acting in the opposite capacity, that some additional illustration may be necessary here. Through the nerves is established the connection between the muscles, not only that connection by which muscles combine to one effort, but also that relation between the classes of muscles by which the one relaxes while the other contracts. I appended a weight to a tendon of an extensor muscle, which gently stretched it and drew out the muscle; and I found that the contraction of the opponent flexor was attended with a descent of the weight, which indicated the relaxation of the extensor. To establish this connection between two classes of muscles, whether they be grouped near together, as in the limbs, or scattered widely as the muscles of respiration, there must be particular and appropriate nerves to form this double bond, to cause them to conspire in relaxation as well as to combine in contraction. If such a relationship be established, through the distribution of nerves, between the muscles of the eye-lids and the superior oblique muscle of the eye-ball, the one will relax while the other contracts.

The course of enquiry leads us, in the next place, to observe the vicinity of the root of this fourth nerve to the origin of the respiratory of the face, and we find them arising from the same track of fibrous substance. The column of medullary matter, which constitutes that part of the medulla oblongata from which the respiratory nerves arise, terminates upwards, or at its anterior extremity, just under the corpora quadrigemina, and there the fourth arises. Is it possible, then, we say, that there can be any correspondence between the general act of respiration and the rolling of the eye? Led thus to make the experiment, I was gratified to find it so easy to give the proof. On stopping the nostrils with the handkerchief, every effort to blow the nose will be attended by a rapid rising of the cornea under the upper eye-lid. And on every occasion when the eye-lids suffer contraction through the agency of the respiratory nerve of the face, as in sneezing, the eye-ball is rolled upwards, undoubtedly through the agency of the fourth nerve.

It is plain that we must consider the nerves and muscles of the eye-lids in a double capacity—in their voluntary and involuntary actions. In the first, the motions of the eye-lids combine with the whole muscles of the eye-ball, as we may perceive in the voluntary contractions and squeezing of the eye; but in the insensible and involuntary motions of the eye-lids there would be no sympathy with the muscles of the eye-ball, and therefore no correspondence in the motion of these parts, without a nerve of the nature of the fourth; that is, a nerve which, having diverged from the root of the respiratory nerves, takes its course to the oblique muscles. In one word, the connection of its root declares the office of this nerve.

The expression of the eye in passion confirms the truth of this relation being established by a respiratory nerve, and, consequently, by a nerve of expression. In bodily pain, in agony of mind, and in all this class of passions, the eyes are raised and dragged, in conjunction with the changes to which the other features are subjected. If it be asked now, as it has been asked for

some hundred years past, why the fourth nerve goes into the orbit, where there are so many nerves; why it is so distant in its origin from the other nerves; and why it sends off no twig or branch, but goes entirely to one muscle of the eye? the answer is, to provide for the insensible and instinctive rolling of the eye-ball; and to associate this motion of the eye-ball with the winking motions of the eye-lids; to establish a relation between the eye and the extended respiratory system: all tending to the security or preservation of the organ itself.

OF THE MANNER IN WHICH THE EYE ADAPTS ITSELF TO THE DISTANCE OF OBJECTS.

This is a question which many have endeavoured to answer, and many have failed: the proof of this is, that there is not *one* explanation of the manner in which the eye adapts itself to the distance of objects, but *many* explanations equally ingenious.

One opinion is, that the eye is at rest when we see the distant parts of a landscape, but that the direction of the eye to the nearer objects is attended with an effort. This effort is the action of the straight muscles of the eye compressing the ball of the eye, so as to lengthen the axis as much as is necessary to allow the pencils of rays to unite in points upon the retina.

To this opinion it is objected, that in some animals the sclerotic is hard, and not capable of changing its figure; that in man the pressure would be unequal; that the unelastic retina would be thrown into irregular folds; that these muscles, being voluntary muscles under the will, we should be more conscious of their operation than we are; and that, while the mind remains attentive to distant objects, no voluntary exertion of these muscles can affect the distinctness of the objects. Again, to make the eye change its accommodation from the distinct vision of objects, at six inches to fourteen feet five inches, would require such a pressure as might

lengthen the axis of the eye one tenth part, which again would form an oval that would derange the retina.

Another opinion is, that when the eye sees the nearest objects it is at rest, and that, in attending to distant objects, the straight muscles draw back the fore part of the eye into the socket, and thus shorten the axis. To this opinion, of course, the same objections lie as to the supposition that the axis is lengthened by the operation of the muscles.

I must say, that it appears to me, if the effect contemplated were referable to the changing the configuration of the eye, we should be sensible of a shift in the position of all objects seen lateral to the axis of vision, and that, by looking to objects afar off, we should diminish or extend the field of vision laterally. I can observe no such effect.

There are some who have entertained an opinion, that the iris, by its contraction, operates so on the circular margin of the cornea, where it is connected with the sclerotic coat, as to make the cornea more convex, and thus increase its power of concentrating the rays, and enable the eye to see near objects distinctly. To account for this power in the iris, Dr. Jurin, the proposer of this hypothesis, supposes that there is a greater muscular ring in the margin of the iris connected with the edge of the cornea; the existence of these muscular fibres is not demonstrated; but he says, since the lesser muscular ring in the inner margin of the iris is not proved by ocular inspection, and yet is justly inferred from its effects, viz. the contraction of the pupil; in the same way, "the change of conformation in the eye has not yet been adequately accounted for, but may be fairly made out by supposing the existence of the greater muscular ring." His conclusion is in these words: — "When we view objects nearer than the distance of fifteen or sixteen inches, I suppose the greater muscular ring of the iris contracts, and thereby reduces the cornea to a great convexity; and, when we cease to view these near objects, this muscular ring ceases to act, and the cornea, by its spring, returns to its usual convexity, suited to fifteen or sixteen inches: in which condition

the elasticity of the cornea on the one side, and the tone of the muscular ring on the other, may be considered as two antagonists in a perfect equilibrium."

To this opinion it is objected, that the iris is not rooted in the cornea, but in the sclerotic coat, which is firm in man, and inflexible in many animals. We have also to consider, that this delicate and invisible circle of muscular fibres has not only to contract the margin of the cornea, but, in this action, to alter the configuration of the whole eye. The eye-ball is a whole equally distended, and no part of it can suffer contraction without a resistance from the whole of the coats; besides, in this case, the alternation of light and the brightness of objects would be perpetually obscuring the image, by the play of the iris causing an alteration of the focus of the cornea. But Dr. Jurin did not attribute the whole effect to the action of the iris. He thus explains the use of the fluid surrounding the lens and the membranous capsule:—When the eye is to be suited to greater distances, he supposed that the ligamentum ciliare contracts its longitudinal fibres, and, by that means, draws the part of the interior surface of the capsule, into which these fibres are inserted, a little forward and outward. By this action, he supposed that the fluid within the capsule of the lens flows from the middle towards the margin; and, consequently, the centre of the capsule of the lens is reduced to a less degree of convexity; and that the elasticity of the capsule, and the tone of the ligament, may be looked upon as two antagonists perfectly in equilibrio with one another. In the state of rest, the eye is conceived, by Dr. Jurin, to be adapted to the middle distance; by the increase of the convexity of the cornea, to be adapted to nearer vision; and, by the change in the capsule of the lens, to be fitted to distant objects.

To this last supposition it is objected, that there is a simplicity in the operations of Nature; that the change wrought upon the capsule of the lens is insufficient to account for the whole effect, and that, therefore, there is a presumption that it has no share in producing the change; that there are no muscular fibres in the ciliary

processes; and, lastly, that this fluid, being of density but little, if at all, removed from the aqueous humour, any alteration of its form can have but a very insignificant effect.

It has occurred to others *, that the oblique muscles of the eye-ball, being thrown in opposite directions round it, they may have the effect of elongating the axis of the eye; again, that the action of the orbicularis muscle of the eye-lids, by compressing the eye-ball, assists in accommodating the eye for seeing near objects more distinctly. Dr. Monro makes a set of experiments to prove the effect of the orbicularis muscle of the eye-lids; but I conceive that he has deceived himself, in ascribing to the compression of the eye-lids an effect partly produced by a voluntary effort, but in a way which is not understood, and partly by the contraction and dilatation of the pupil, from the degree of opening of the eye-lids. If he be right in his way of accounting for the effects produced in the experiments which he details, they ought to have the effect of precluding the necessity of all further hypothesis; so fully does the action of the orbicularis muscles seem to him adapted to the end proposed. In the first experiment, when he opened his eye-lids wide, and endeavoured to read a book, the letters on which were so near the eye as to be indistinct, he found that he could not do it. In the second experiment, keeping the head in the same relation to the book, he brought the edges of the eye-lids within a quarter of an inch of each other, and then made an exertion to read, when he found he could see the letters and words distinctly. When I try this experiment I find the action of the eye-lids to have no sensible effect, unless they are brought very close together: then I do, indeed, find that they have a most remarkable effect. But, in this situation, the eye-lids cover the cornea so much, that if they have any effect at all upon the cornea, it must be to compress and flatten it, and not to give it a greater convexity. The smaller the opening of the eye-lids, the greater I found the effect: I con-

* Hambergerus, Briggs, Keil, Monro.

ceive it to be produced by the optical effect of the eye-lashes correcting the too great converging of the rays; and the same effect I found to be produced by the marginal hairs of two flat camel-hair brushes, although the eye-lids were kept open. Dr. Monro concludes that, in this action of the eye, 1st, the iris; 2dly, the recti muscles; 3dly, the two oblique muscles; and, 4thly, the orbicularis palpebrarum, have all their share in accommodating it to the distance of objects, and in giving perfect vision.

Very ingenious experiments are made by Dr. Young*, to determine whether there be any change in the length of the axis of the eye-ball. He considers it as necessary, to account for the power of the eye in adapting it to the distance of objects, that the diameter should be enlarged one seventh: its transverse diameter diminished one fourteenth; and the semi-diameter shortened one thirtieth of an inch. To determine this he fixed the eye, and at the same time he forced in upon the ball of the eye the ring of a key, so as to cause a phantom very accurately defined to extend within the field of perfect vision; then, looking to bodies at different distances, he expected, if the figure of the eye was altered, that the spot, caused by the pressure, would be altered in shape and dimensions; he expected that, instead of an increase of the length of the eye's axis, the oval spot caused by the pressure of the key, resisting this elongation, should have spread over a space at least ten times as large as the most sensible part of the retina: but no such effect took place; the power of accommodation was as extensive as ever, and there was no perceptible change either in the size or in the figure of the oval spot. Again, he placed two candles so as exactly to answer to the extent of the termination of the optic nerve: he marked accurately the point to which the eye was directed; he then made the utmost change in its focal length, expecting that, if there were any elongation of the axis, the external candle would appear to recede outward upon the visible space; but this did not happen; the apparent

* Philos. Trans. for 1810.

place of the obscure part was precisely the same as before.

A favourite opinion of late has been, that the lens has a power of altering its degree of convexity, and thus accommodating itself to the distance of objects. As to the fibrous structure of the lens, there can be no doubt: first it is rent by fissure, then split into lamina, and can be finally teased out into fibres.

This structure was first observed by Leeuwenhoeck: he has these words: — "Porro vidi corpus crystallinum ex tam tenuibus coacervatis constare squamis ut ubi eas oculo dimetior, dicere cogar, pluris bis millenis sibi invicem incumbere; ubi enim corpus crystallinum ab ejus membranula seperassem, ejus adhuc axis, ubi crassissimum erat, (non enim est perfecte rotundum, sed aliquo modo planum,) duas tertias pollicis partes retinebat; ergo a centro ad circumferentiam est tertia pollicis pars, atque quoniam, ex dimensione mea 600 pili lati pollicis quadrati, longitudinem conficiunt 200 pili lati pollicis tertiam partem adæquare debent. Atque nunc video ubi denæ squamæ sunt coacervatæ, eas capilli nostri diametrum nondum adæquare; ergo his 10 cum 200 multiplicatis, sequetur, ut dictum, plures 2000 squamas in corpore crystallino esse coacervatas. Porro vidi singulas has squamas ex filamentis, concinno ordine juxta se positis, constare adeo ut singulæ squamulæ unum filamentum sint crassæ; et ut hanc substantiam fibros eam ex qua corpus crystallinum constat ob oculos ponerem, eam lineis in circulum ductis quantum pote designavi."

The fibrous structure and muscularity of the lens was brought forward by Descartes, as explaining some actions of the eye; but was again neglected, till more lately, that it has been revived by the insertion of Dr. Young's Observations on Vision in the Philosophical Transactions.* The following are Dr. Young's observations on the appearance of the lens: — "The crystalline lens of the ox is an orbicular convex transparent body, composed of a considerable number of similar

* See vol. for 1793.

coats, of which the exterior closely adheres to the interior. Each of these coats consists of six muscles, intermixed with a gelatinous substance, and attached to six membranous tendons. Three of the tendons are anterior, three posterior: their length is about two thirds of the semidiameter of the coat; their arrangement is that of three equal and equidistant rays, meeting in the axis of the crystalline: one of the anterior is directed towards the outer angle of the eye, and one of the posterior towards the inner angle, so that the posterior are placed opposite to the middle of the interstices of the anterior; and planes passing through each of the six, and through the axis, would mark on either surface six regular equidistant rays. The muscular fibres arise from both sides of each tendon: they diverge till they reach the greatest circumference of the coat, and, having passed it, they again converge till they are attached respectively to the sides of the nearest tendons of the opposite surface. The anterior or posterior portion of the six, viewed together, exhibits the appearance of three penniform radiated muscles. The anterior tendons of all the coats are situated in the same planes, and the posterior ones in the continuations of these planes beyond the axis. Such an arrangement of fibres can be accounted for on no other supposition than that of muscularity. The mass is enclosed in a strong membranous capsule, to which it is loosely connected by minute vessels and nerves; and the connection is more observable near its greatest circumference. Between the mass and its capsule is found a considerable quantity of an aqueous fluid, the liquid of the crystalline."

These muscular fibres could not be excited by Dr. Young so as to change the focal power. The same author states, that nerves enter the lens. I cannot say I see any tending that way. Supposing that these are muscular fibres*, from their closeness and direction, they would stand acknowledged as forming the

* The fibrous structure of the lens is represented according to Leeuwenhoeck.

strongest and most powerful muscle of its size in the whole body; yet they act only on themselves, which requires the least possible degree of power. Again, how are they relaxed? What power is their antagonist? As to the tendons, I do not see their use. Does not the lens act merely on itself? It can require no concentrating of its fibres into tendons; for tendons are found in other parts of the body only where it is necessary to concentrate the whole power of the muscle so as to operate on one point. We know that the transparency of a substance depends on a certain arrangement of its fibres. Would not this change of position in the lens affect its transparency? The effect is observed in the cornea.

However successfully the admirable methods of Dr. Young may have decided the matter as to the conformation of the eye-ball, he has not satisfied me that the power of adaptation is in the lens.

We learn from Sir Everard Home *, that Mr. John Hunter had proved the lens to be laminated, and those laminæ to be composed of fibres; and, upon the same authority, we learn that his opinion was in favour of the muscularity of its structure. Sir E. Home wished to follow out this subject, by including it in the Croonian Lecture. He, with the assistance of Mr. Ramsden, thought he had determined that a patient, after the extraction of the cataract, still retained the power of adapting the eye to the distances of objects. Dr. Young, on the contrary, is positive that, in those who have lost the crystalline humour by operation, the focal distance is totally unchangeable.

By Mr. Ramsden's ingenious contrivance, the head was fixed accurately, and at the same time a microscope was adapted to observe the changes in the convexity of the cornea, as the eye was directed alternately to near and to distant objects. In these experiments, the motion of the cornea became distinct; its surface remained in a line with a wire which crossed the glass of the microscope when the eye was adjusted to the distant

* See Philos. Trans.

objects, but projected considerably beyond it when adapted to the near ones, and the space through which it moved was so great as readily to be measured by magnifying the divisions on the scale, and comparing them. In this way it was estimated that it moved the 830th part of an inch (a space distinctly seen in a microscope magnifying 30 times), in the change from the nearest point of distinct vision to the distance of 90 feet.

In the evidence from anatomical structure, I cannot think Sir E. Home so happy. He was desirous of determining, more accurately than had hitherto been done, the precise insertion of the tendons of the four straight muscles, so as to know whether their action could be extended to the cornea or not: he found them to approach within $\frac{1}{8}$ of the cornea before their tendons became attached to the sclerotic coat. But he did not stop here: he stripped off with them the anterior lamina of the cornea. Now, as it is supposed, in these experiments, that the action of the recti muscles upon the sides and back part of the ball compresses the humours, and makes them flow forward so as to distend the cornea; if the extremities of the tendons be inserted into the edge of the cornea, and even pass over it, as Sir E. Home has demonstrated, their effect would be to flatten the cornea, by drawing out and extending its margin. This is a circumstance which Dr. Monro has remarked; and he has found "all the tendinous fibres of the recti muscles firmly attached to the sclerotic coat at the distance of a quarter of an inch from the cornea, and no appearance that any part of them, or that any membrane produced by them, is continued over the cornea."

Dr. Young's experiment appears to be decisive of the question as regards the cornea. He destroyed the influence of the cornea, and still the eye possessed its range! He did this in the most ingenious manner, by inserting upon his eye a lens with its circular case full of water. The water touched the cornea, and intervened betwixt the cornea and the glass. Consequently, as the power of the cornea exists only by the difference of density of the air and cornea, and as by the interposition of water this power was destroyed, the eye con-

tinuing in possession of its ability to adapt itself to distances, this property could not depend on the cornea.

Amongst the variety of opinions, the innumerable, ingenious, but contradictory experiments for discovering the manner in which the eye adapts itself to the distance of objects, I am, for my own part, much at a loss to determine which I should prefer. I have often doubted whether these experimenters were not in search of the explanation of an effect which has no existence. I have never been able to determine, why a very slight degree of convexity in the cornea of a short-sighted eye should be so permanent during a whole lifetime, were the cornea elastic in the manner supposed, and capable of being altered in its convexity by the action of muscles. A near-sighted person, with the assistance of a concave glass, can command the objects to the distance of some miles, and, with the glass still held to his eye, can see minute objects within three inches of the eye. Now, I cannot conceive how the concave glass should give so great a range to the sight: as there can be no change in the glass, it must be the eye which adapts itself to the variety of distances; yet, without the glass, it cannot command the perfect vision of objects for a few feet. Again, a short-sighted person sees an object distinctly at three inches distant from the eye; at twelve feet, less distinctly; and, when he looks upon the object at twelve feet, the objects beyond it are confused, just as they appear to other men; but when he directs his attention to the more remote objects, those nearer become indistinct. Now, this indistinctness of the object, seen when he examines narrowly the objects beyond them, would argue (did we admit this muscular power in the eye of adapting itself to objects) that the cornea or the lens has become less convex, were we not previously convinced that the utmost powers of the eye could not bring the object at the distance of twelve feet, or any other intermediate distance, to be more distinctly seen than the fixed and permanent constitution of the eye admits.

I cannot help concluding, therefore, that the mechanism of the eye has not so great a power of adapting the

eye to various distances as is generally imagined, and that much of the effect attributed to mechanical power is the consequence of the motion of the pupil, the effect of light and of attention. An object looked upon, if not attended to, conveys no sensation to the mind. If one eye is weaker than the other, the object of the stronger eye alone is attended to, and the other is entirely neglected: if we look through a glass with one eye, the vision with the other is not attended to. Now, objects, as they recede from us, become fainter and fainter in their colours, and the general effect upon the eye is different from those which are near; and as it happens that the mind must associate with the sensation before it be perfect, there is, consequently, an obscurity thrown over distant objects when we contemplate near ones; as, on the other hand, the images of near ones are not attended to when the mind is occupied with distant ones, although they be nearly in the line with the distant object examined. The mind, not the eye, harmonises with the state of sensation, brightening the objects to which we attend. In looking on a picture, or a panorama, we look to the figures, and neglect the background; or we look to the general landscape, and do not perceive the near objects. In short, we experience the whole phenomena presented to the eye when the shades and colours of nature are presented to us from a plane surface, as when the eye opens on all the varieties of a natural scene. It cannot be an adaptation of the eye, but an accommodation and association of the mind with the state of impression.

OF VISION.

The eye is certainly the noblest of the organs of sense. It is that with which we should part the most unwillingly, and of which, when deprived, we are most helpless. A celebrated philosopher says, how much more noble is that faculty by which we can find our way in the pathless ocean, traverse the globe, determine its figure and dimensions, delineate every region of it;

by which we can measure the planetary orbs, and make discoveries in the sphere of the fixed stars! While another says, it is the universe itself! We are present with the stars which beam upon us, at a distance that converts to nothing the wide diameter of our planetary system. The other senses are the ties which bind us to our dwelling-place, whilst the eye retains the unbounded freedom of the celestial origin.* Yet, notwithstanding the perfection of the sense of seeing, much of this perfection is gained by the other senses, and particularly by that of touch. If the human body were motionless and inert, the sensation conveyed by the eye would be very imperfect: we should be able to conceive neither the distance nor the figure of objects. But, as it is, the visible magnitude of an object is the sign of its real magnitude; which knowledge we have acquired by other means. When we look upon an object, we have its visible figure before us, as the sign of its real figure, which, by experience, that is, by motion of the hand, by approach, and the actual comparison with our own bodies, we have in a manner more perfect previously ascertained. Without this combination of actual experience and true knowledge, with the associated signs in the eye, vision would be a continual delusion.

Upon other occasions, we are apt enough to acknowledge the powers of association. But the connection of ideas is in no instance more constant and secret than in those conveyed by sight and touch. When a solid body is presented to view, we see only the light and shade; but this raises in our mind the associated ideas from the sense of touch, of solidity, convexity, and angularity, "the visible idea exciting in us those tangible ideas," which, in the free and promiscuous exercise of our senses, usually accompany it. It is thus that we attribute to the sense of sight what is the act of the memory and judgment.†

We have seen that the picture of an object is formed in the bottom of the eye. It was formerly sufficient to

* Brown.

† See Dr. Jurin on Mr. Molyneux's problem, Smith's Append. p. 27.

say, that the mind contemplates this image. We should say now, that this image is conveyed into the sensorium by the optic nerve. This is an hypothesis merely; and we have no more consciousness of the object being in the brain or sensorium than in any other part of the body: we may rather say, that the impression made on the organ, nerves, and brain, is followed by sensation, and that the intelligence is the joint operation of the whole.* Lastly, the metaphysician calls our sensations the signs of external objects; because the object itself is not presented to the mind, nor is there an actual resemblance betwixt the object and the sensation of it, but merely a connection established by nature, as certain features are natural signs of anger; or by art, as articulate sounds are the signs of our thoughts and purposes.

We are now naturally let to the consideration of some points, the full comprehension of which require the knowledge both of anatomy and of the principles of optics.

PARALLEL MOTION OF THE EYES.

The axis of the eye is a line drawn through the middle of the pupil and of the crystalline lens, and which, consequently, falls upon the middle of the retina. The axes of the eyes, it is evident, are not always parallel; for when both eyes are directed to a near object, the axes of the eyes meet in that object; but when we direct the eyes to the objects in the heavens, they may be considered as perfectly parallel in their axis, though, per-

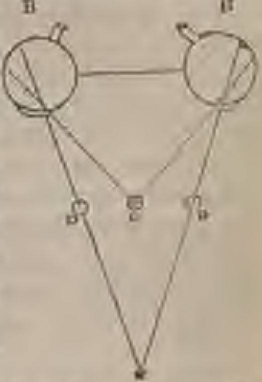
* Euclid, and others of the ancients, contended that vision was occasioned by the emission of rays from the eye to the object. He thought it more natural to suppose, that an animate substance gave out an emanation, than that the inanimate body did. In 1560, the opinion was confirmed that the rays entered the eye. — The sensation was not always believed to be in the retina: it was by some believed that part of the sensation was to be attributed to the crystalline. Kepler, in 1600, showed, geometrically, how the rays were refracted through all the humours of the eye so as to form a distinct picture on the retina; and also he showed the effect of glasses on the eyes. See further, regarding the opinions of the ancients, Boerhaave, Prælect. Acad. tom. iv. p. 282.

haps, not then mathematically so. To an observer, the eyes seem always moving in parallel directions; but Nature has given us the power of varying them so, that we can direct them to the same point, whether remote or near. This, however, is in some measure acquired by custom, and lost by disuse. A child has much difficulty in altering the distance of its eyes, which is the occasion of the vacancy of its stare; and we observe that a patient who has long lost one eye is incapable of directing the axis of the blind eye without looking with the other, and, even then, the blind organ does not follow the other with that perfect accuracy which exercise gives when both eyes are sound. By practice and straining, the axes of the eyes may be further altered from the natural parallelism. A child born blind turns its eyes in every possible direction, as it does its hands, without concert; but when the vision is perfect, there is a power which directs the eyes and leads to parallelism.

There is a particular sensible spot in the retina, which makes it necessary to distinct vision that this spot shall receive the concentrating rays of light; and the natural constitution of the eyes is such, that this spot in one eye shall have a relation to that of the other: that the axis of both should be accurately in the middle of the eye-ball, the child very soon acquires the power of directing the eyes with a simultaneous and corresponding effort.

By voluntary squinting or depressing one of the eyes with the finger, objects appear double, because the optic axis is changed in the distorted or depressed eye, and the picture is no longer painted on corresponding points of both retinæ. This simple experiment leads us to consider what is the constitution and correspondence of the eyes, that, when each has the picture of the object impressed upon it, we should only see it single if the eyes are sound and perfect.

For example: the object A is exactly in the centre of the axis of both eyes, consequently, it is distinctly seen; and it appears single, because the rays from it strike upon the points of the retina opposite to the pupils in both eyes. Those points have a correspondence; and the object, instead of appearing double, is only strengthened in the liveliness of the image. Again, the object B will be seen fainter, but single, and correct in every respect. It will appear fainter because there is only one spot in each eye which possesses the degree of sensibility necessary to perfect vision; and it will appear single, the rays proceeding from it having exactly the same relation to the centre of the retina in both eyes. Though they do not fall on the centre of the retina, they fall on the same side of the centre in both eyes. But if the eyes are made to fix steadfastly on an object, and if another object should be placed before the eyes within the angle which the axis of the two eyes make with the first object, it will be seen double, because the points of the retina, struck by the rays proceeding from the nearer object, do not correspond in their relation to the central point of the retina. Thus, the eyes B B, having their axis directed to A, will see the object C double somewhere near the outline D D. Because the line of the direction of the rays from that body C does not strike the retina in the same relation to the axis A B in both eyes. Upon this principle, we may easily explain why objects which are much nearer the eyes, or much more distant from them than that to which the two eyes are directed, appear double. Thus, if a candle is placed at the distance of ten feet, and I hold my finger at arm's length between my eyes and



the candle, when I look at the candle, I see my finger double; and, when I look at my finger, I see the candle double. This double vision occurs to us all frequently; but, unless we make the experiment purposely, we do not attend to it. Many other instances of the harmony, and of the want of it, in the eyes, particularly the reverse of what these diagrams show, may be easily produced, viz. the seeing two objects single; for, if we look at a halfpenny and a shilling, placed each at the extremity of two tubes, one exactly in the axis of one eye, and the other in the axis of the other eye, we shall see but one piece of coin, and of a colour neither like the shilling nor like the halfpenny, but intermediate, as if the one were spread over the other.

This relation and sympathy between the corresponding points of the two eyes is, therefore, to be considered as a general fact, viz. that pictures of objects, falling upon corresponding points of the two retinas, present the same appearance to the mind as if they had both fallen upon the same point of one retina; and pictures upon points of the two retinas which do not correspond, and which proceed from one object, present to the mind the same apparent distance and position of two objects, as if one of those pictures were carried to the point corresponding with it in the other retina.

Several animals, we see, direct their eyes by very different laws from those which govern the motion of ours; but we are not to reason upon their sensations by the laws of vision of the human eyes: we must take it as a principle, that Nature has been bountiful to them also; and that the result of organisation in their eyes is perfect vision.

In birds (if we except the owl) the eyes diverge, and are directed to opposite sides. As the owl seeks his prey in the night, it may be necessary to the distinctness of his vision in weak light, that both eyes be directed to the object. Most fishes have their eyes directed laterally, though there are exceptions; as those fishes which are flat, and swim at the bottom, have their eyes directed upward. In many insects, the surface of the eye has no resemblance to the cornea of viviparous animals; but,

when examined with the microscope, it is seen to consist of a number of tubercles, each of which is as a distinct eye. In others, the eye is removed to the extremity of the movable tenaculæ. Very large animals, as the whale, elephant, rhinoceros, hippopotamus, have, in proportion to their bodies, very small eyes: so have the animals which live much under ground; and, in general, a large eye is a sign of the animal being able to see in obscure light, because there is proportionably a greater number of rays admitted into the eye. For the same reason fishes have a peculiarly large eye and dilatable pupil, because the water is a more obscure medium, and, from the occasional roughness of its surface, much darkened and variable.

We must conclude, that in these varieties of the eyes, where there is a difference in number, position, and natural motion, there are different laws of vision adapted to these peculiarities and the exigencies of the animals.

If we are to judge from analogy, we may suppose, that in many animals there is no correspondence between points of the two retinas, or it is of a different kind from ours. In those which have immovable eyes, the centre of the two retinas will not correspond so as to give the idea of one object, but of distinct objects, and in their respective places; and, indeed, I conceive that in such the offices of the eye must be much circumscribed: they will, perhaps, only distinguish degrees of light; and in such as turn their eyes in all directions, independently of each other, they would seem to possess a perception of the direction in which they move them, as we have of the motion of our arms. This consideration leads to a very curious subject.

SQUINTING.

The student cannot feel satisfied on the subject of the motions of the eyes, unless he understands this very common defect.

In the first place, we must observe, that there is a complaint, where, the muscles of the eye being primarily affected, the eyes are distorted. The images then

fall on parts of the retina which have no correspondence, and the effect for the time is double vision. Afterwards there is single vision, without amendment of the distortion, but merely from the weaker impression on one eye being neglected. But this is not the very common case of squinting, where, with very evident obliquity of the eyes, there is single vision from the beginning. This common case of squinting, I apprehend, could not be understood whilst there was a neglect of the classification of the muscles of the eyes and an ignorance of their distinct offices.

It now appears, that the *recti* muscles of the eye-ball are in activity during attention to the impression on the retina; but that when that attention is withdrawn, the *recti* muscles are relieved, and the eye-ball is given up to the influence of the oblique muscles. This takes place in sleep, in fainting, and intoxication. When the nerve is deficient in one eye, and the sensibility less than in the other, the *recti* muscles are unexerted; the *obliqui* preponderate; and the state of equilibrium betwixt the *two obliqui* is when the eye-ball is turned, and the pupil presented upwards and inwards. Thus we perceive that by founding on a just view of the anatomy the whole train of facts connected with this curious subject accord, and the explanation of squinting is simple. Whereas, before it was necessary to take a great deal for granted, and to suppose an *effort* of the muscles of the weak eye necessary to draw it out of the way of the other one; it being presumed that a weaker impression, in addition to a full and natural one, must be an injury to vision. We have seen, that there is a point in both retinas more acutely sensible to the impression of light and the image of objects, than any other part of all its concave surface. In a sound eye, this point is immediately opposite to the pupil. There is a coincidence betwixt this point and the axis of the eye; and when we look to an object, its image strikes this point of the retina.* If the greater sensibility of the nerve

* This was M. de la Hire's opinion. — He had an idea also that squinting was produced by the obliquity of the object. Both of these opinions are refuted by Dr. Jurin.

should lie in its proper place, and some cause should produce such an action of the muscles and distortion of the eye as we see in a squint, then the image will be double; for it no longer falls on corresponding points of the retina of each eye, and separate images are conveyed to the brain. If, however, this distortion continues, the single vision is gradually restored. Is there, then, in this case, produced a new correspondence betwixt points of the retina which were before discordant? We find that this is not the case, by a very simple experiment. — In a person who squints, one of the eyes is directed to the object and the other appears to be turned from it: if the sound eye be shut, and the person be directed to look to an object with the other, it is directed to it with the proper and natural axis. Now this shows us that the sensibility of the proper spot in the bottom of the eye is not altogether lost. But most people who squint have a defect of vision in the distorted eye, while the eye directed to the object has its natural sensibility to light. Now the mind does not attend easily to two impressions, the one being weaker than the other: in a short time the weaker impression is entirely neglected, and the stronger only is perceived. — So in squinting, the impression on the weak eye in a short time ceases to be attended to, the strong and vivid impression is alone perceived, and single vision is the consequence; while the eye, thus naturally excited, has the due degree of energy and activity of the recti, or voluntary muscles, but the other eye has no impression, and no such excitement as the natural stimulus on the retina affords to the recti muscles, and therefore it is drawn into that position which is its state of rest; the eye is as if asleep.

What is very extraordinary in squinting, is the correspondence in the muscles of the eye, notwithstanding the great distortion of the eye-ball; for, when both eyes are open, as the sound eye turns in all variety of directions to the surrounding objects, the other eye still follows it, but preserves its distance, so as in a manner to avoid all interference. But this is explained on the view stated. There is a preponderance of the oblique muscles over the recti, by which the eye is turned from

the true line of the axis, without being altogether withdrawn from the influence of voluntary effort. Blows on on the head, drinking and smoking, and a variety of irritations, occasion convulsions and distortion of the eyes, but they, at the same time, cause double vision. This is evidently produced by the affection of the muscles moving the eye-ball (since a change of the sensibility of the retina could not give occasion to distortion during a state of insensibility); we may, therefore, conclude, that squinting is sometimes the consequence of irregular action of the muscles, independent of the condition of the retina.*

We can distort our eyes by an unnatural effort, but we cannot squint, that is to say, we can bring our eyes into such a forced situation that we cannot see any thing distinctly; but we cannot keep one eye distinctly upon an object, and turn the other from it. — Such a position of the eyes, at least, (and which is exactly that of those who squint unintentionally,) I cannot by any means accomplish.† This shows the strict correspondence betwixt the moving muscles of the eye-balls. By this experiment, we shall find the difficulty of that method of correcting the squint proposed by Dr. Jurin, or of commanding motions of the eyes different from those which have been bestowed by nature, or acquired by habit. But habit I believe to be much more seldom the origin of squinting than is generally supposed. It is

* In Smith's Optics, there is a case of squinting and double vision occasioned by a blow. In Buffon's Dissertation, in the Acad. Roy. des Sc. 1743, squinting after long continued pain of the head. In the Mem. Roy. de l'Acad. des Sc. 1718, Hist. p. 29., there is a curious instance of false vision. I find also quoted several cases of strabismus from sudden fright, in *Ephem. Germ. cent.* 3. & 4. *obs.* 152. *p.* 349. Ib. dec. 3. an. 8. & 11. ob. 57. d. 114. Ib. dec. 3. an. 9. & 10. obs. 67. "Novi Juvenem paralysi obnoxium, cui cum cæteris oculi sinistri musculis relaxatis, *adducens* fortius contraheretur propter oculum ita distortum objectum quodcunque duplex apparebat, nec quod verum esset distinguere potest." *Willis de anima Brut. P. Physiol.* p. 77. An instance of the loss of corresponding motions of the eyes, and strange illusions of sight. See in the Enquiry into the Nature of Mental Derangement by Dr. Crichton, vol. i. p. 147.

† It is said that astronomers, who are much used to attend only to the impressions of one eye, are sometimes able to squint at pleasure. See Mr. Home, Phil. Trans. 1797, p. 17.

said, by Dr. Reid and others, that we see young people, in their frolics, learn to squint, making their eyes either converge or diverge when they will to a very considerable degree: why should it be more difficult for a squinting person to learn to look straight when he pleases? The reason of the greater difficulty is obvious, — that in making the eyes converge or diverge the will is acting upon both eyes equally; but to distort one eye inward or outward, and at the same time to keep the other fixed, is to me like an absolute impossibility. But the reason of the difficulty of correcting squinting is, as I have stated, that the voluntary muscles of the eye are deficient in their natural stimulus, which is the exercise and enjoyment of the sense of vision.

A frequent effect of the weakness left by long fevers in children is a squint which gradually goes off as the strength is restored. It is observed, also, that squinting and double vision are, in some fevers, a concomitant with delirium and phrenitis. This symptom proceeds, in all likelihood, from an unequal tension of the muscles of the eye-ball. The double vision is the effect of discordance in the action of the muscles.*

OF THE EAR.

OF SOUND, AND OF THE EAR IN GENERAL.

Sound is the effect of impression on the auditory nerve, by which a corresponding change is produced in the brain, and the perception of sound excited. It may be produced by the vibration and motion of the air, but not without the intervention of solids. The human

* This has been more lately explained by the author in a distinct dissertation, and he hopes to pursue the subject further. See *Philos. Trans.*

voice, for example, does not depend merely on the percussion of the air, but on that vibration, as combined with the tension and consequent vibration of the glottis, excited by the current of air. However, the vibrations which produce sound are not those which are visible or are felt by the finger; sound depends on a more minute motion of the particles of bodies, and is only cognizable by the appropriate organ, the ear.

There is no body impervious to sound, or, in other words, incapable of transmitting the vibration. That sound is communicated through the medium of the air, we know from the circumstance, that a bell, when struck in a vacuum, gives out no sound; and again, from this, that the condensed state of the atmosphere affords an easier communication of sound, and conveys it to a greater distance. The velocity of the impression transmitted by the common air is computed at 1130 feet in a second; and sound, when obstructed in its direct motion, is reflected with a velocity equal to that with which it strikes the solid body by which its progress is interrupted.

That water conveys the vibrations producing sound has been proved by experiment. It was once the saying of naturalists, that to suppose fishes to have the organ of hearing, would be to conceive that an organ were bestowed upon them without a possibility of its being of use. But we are assured of the fact, that, on the tinkling of a bell, fishes come to be fed *; and it was the custom for the fishermen on the coast of Britany to force the fish into their nets by the beating of drums †, as our islanders are at present accustomed to do when the larger fish get entangled amongst the rocks. We are told, that in China they use a gong for the same purpose. These facts were once of importance, though more accurate observation has now made them super-

* Boyle.

† M. l'Abbé Nollet, Acad. R. des Sciences. Naturalists were very incredulous of the effects said to be produced by music on lobsters. Some may be so still; but there is no doubt that they possess the organ of hearing. See *Scarpa Disquisitiones Anatomicæ de Auditu in Insectis*, &c.

fluous. The Abbé Nollet took much pains to decide the question, whether water was a medium for sound. After considerable preparation, and acquiring a dexterous management of himself in the water (for which he takes great merit to himself), he found that he could hear under water the sound of the human voice, and even distinguish conversation and music. The human ear being an organ imperfectly adapted to this medium of sound, these experiments do not inform us of the relative powers of air and water in the transmission of sound: But another experiment of the Abbé Nollet proves, what indeed to me is sufficiently evident, from the structure of the ear of fishes, viz. that the water transmits a much stronger vibration than the air. When he sunk under water and struck together two stones which he held in his hands, it gave a shock to his ear which was insupportable, and which was felt on all the surface of his body, like that sensation which is produced when a solid body held in the teeth is struck by another solid body.* He observed, in other experiments, that the more sonorous the bodies struck were, the less vivid was the impression; by which it would appear, that water, though it conveys an impression more strongly to the ear than the air, is not equally adapted to the resonance and variety of tone. Indeed, this is a natural consequence of the water, a fluid of greater density, being in close contact with the sounding body, and suppressing its vibration. In these facts, we shall find the explanation of some peculiarities in the structure of the ears of fishes.

Thus, we see, that the vibration of a solid body is continued through the air, and through water, until reaching the organ of hearing, it produces the sensation of sound. Sound, it will be evident, is also communicated through solids. When we put the ear to one end of a log of wood of thirty feet in length, and strike upon the other, we are sensible of the impression; and when a solid body applied to the bones of the head, or to the

* These experiments were repeated by Dr. Monro. See his Book of Fishes.

teeth, is struck, we are sensible of the noise *; and this is felt even by those who are deaf to impressions conveyed through the air: indeed it is partly in this way that we are to judge whether deafness may be cured by operation, as depending upon some injury of the mechanism of the organ, or whether it be an incurable affection of the nerve, or brain itself. If the sound be perceptible when conveyed through the teeth, or when a watch, for example, is pressed upon the bone behind the outer ear, we are assured that the internal organ is unaffected; and upon enquiring farther into the case, we may find that the deafness proceeds from some disease of the outer tube of the ear, or of that tube which leads into the throat, and that it can be remedied.

GENERAL VIEW OF THE VARIETIES IN THE EARS OF ANIMALS.†

There is in the scale of animals a regular gradation in the perfection of the organ of hearing. But, in the human ear, we find united all the variety of apparatus for communicating the vibration to the internal organ, and along with this the most extensive distribution of nerves in the labyrinth, or inmost division of the ear, to receive that impression.

The ultimate cause of this more complex structure is the greater power with which man is endowed, of receiving through the ear various impressions of simple sounds; language, music, and various modifications of the sense, of which the lower animals are probably incapable.

As, in treating of the anatomy of the eye, we do not attempt to investigate the manner in which light acts upon the retina, in producing the sensation of colours, but endeavour merely to explain the structure of the eye;

* Perhaps we cannot call this sound.

† In the following short account of the comparative anatomy of the ear, although I have taken every assistance in my power from books, I have described the structure, in all the examples, from my own dissections and observations.

to show how the coats support and nourish the humours; how the humours serve to concentrate the rays of light, and assist their impulse upon the retina: so, in the same manner, in explaining the structure of the ear, we need not investigate the philosophy of sound, nor the nature of those impressions which are made by it on the sensorium through the nerves; our views are limited to the structure of the ear: we have to observe the mechanism by which the strength of vibrations is increased and conveyed inward to the seat of the sense, and the manner in which the nerve is expanded to receive so delicate an impression.

The method of studying this subject, which is at once the most instructive and the most amusing, is to trace the various gradations in the perfection of the organ, through the several classes of animals. It is chiefly by comparing the structure of the viscera, and the organs of sense in animals and in man, that comparative anatomy is useful in elucidating the animal economy. For example, in the stigmata and air-vessels of insects and worms; in the gills of fishes; in the simple cellular structure of the lungs of amphibia; in the more complicated structure of the lungs of birds; we observe one essential requisite through the whole gradation, viz. the exposure of the circulating fluids to the action of the air. And in this variety of conformation, we see the same organ so modified as to correspond with the habits and necessities of the different classes of animals. In the same manner, with regard to the circulating system, we are taught the explanation of the double heart in the human body, by tracing the variety of structure through the several classes of animals; from the simple tube circulating the fluids of insects, the single ventricle of fishes and reptiles, the double auricle and perforated ventricle of amphibia, up to the perfect heart of the warm-blooded animal. The organs of generation, and the economy of the fœtus in utero, are, in the same degree, capable of illustration from comparative anatomy. But most especially in the structure of the ear, is there much scope for this kind of investigation. We find such varieties in the ear of reptiles, fishes, birds, and quadru-

peds, as lead us, by gradual steps, from the simpler to the more complex structure.

The simplest form of the organ of hearing is that in which we find a little sac of fluid, and on the inside of the sac the pulp of a nerve expanded. If an animal, having such an organ, breathe air, a membrane closes this sacculus on the fore part; and, by means of this membrane, the vibrations of the air are communicated to the expansion of the nerve through the fluid of the sac. But if the animal inhabits the water only, it has no such membrane to receive the impression; the organ is incased in bone or cartilage, and instead of the exterior membrane, some small bone or hard concreted matter is found suspended in the fluid of the sac nerve. The sound, passing through the waters, is, in such case, conveyed to the organ not by any particular opening, but through the bones of the head; and this concrete substance, partaking of the tremulous motion, communicates an undulation to the fluid, and through it an impression to the nerve.*

For example, in the CRAB and LOBSTER, we find a prominent bony papilla or shell, which is perforated; a membrane is extended across the perforation; and behind this membrane there is a fluid, in which the nerve is expanded, and which receives the impulse conveyed to the membrane. In the CUTTLE-FISH there is no external opening; there is merely a little sac under the thick integuments: this sac has in it a small concretion or bone for receiving the vibration, which, in this animal, is conveyed by a more general impression upon the head than in the instances last mentioned; and the vibration of this loosely-poised bone or concrete, seems equal to the provision of the membrane which, in the crab, closes up the external opening in the perforated shell.

In FISHES, there is a considerable variety of structure.

* It is conceived by some that the antennæ of insects convey to them the vibration of bodies, and that they may be considered as an imperfect variety of this organ. They may receive an impression from the vibration of the air; but as their nerves are nerves of touch, it cannot be sound which they experience.

Those which remain perpetually under water have not the outer membrane, nor any apparatus for strengthening the first-received undulations of sound. But such as lie basking on the surface of the water, and breathe through lungs, have an external opening — a canal leading to the membrane, and behind the membrane, bones to convey the vibration to the internal parts, and these internal parts are nearly as perfect as in terrestrial animals.

In neither of the species of fishes, the cartilaginous nor spinous fishes, is there a proper external opening, as in animals breathing air. They receive the impulse from the water, upon the integuments and bones of the head; but within the head, and in the seat of the sense, they have a most beautiful apparatus for receiving and conveying those general vibrations to the expanded nerve. There is in every ear, adapted to hearing under water, a bone or concretion, placed so as to vacillate easily, and which is destined to agitate the fluid, in which it is suspended, with a stronger vibration than could be produced merely by a general impulse. Besides this provision in fishes, there is a very elegant structure for still further increasing the surface destined to receive the impulse, and for exposing to that impulse or vibration a larger proportion of the expanded nerve. It consists of three semicirclular tubes, which penetrate widely within the bones of the head. They are filled with a fluid, and have in their extremities a division of the nerve which is moved or otherwise affected by the vibration of the fluids contained within the tubes.

There is a slight variety, however, in the ear of cartilaginous fishes. In the head of the SKATE, for example, there is under the skin, at the back of the head, a membrane extended across a pretty regular opening. This, however, is not considered as the opening of the ear; but a passage, like a mucous duct, which is beside it, has given occasion to a controversy between Professors Scarpa and Monro; and it may not be out of place to enquire a little into this disputed point.

We have seen that water conveys the sound of vibrating bodies with a shock almost intolerable to the ear,

and with a particular and distinct sensation over the whole body. We see, also, that, in the greater number of fishes, there is confessedly no external opening, the whole organ is placed under the squamous bones of the head. Yet the cartilaginous fishes, which are supposed to have an external ear, swim in the same element, and are in no essential point peculiar in their habits. And we should receive with caution the account of any peculiarity in the organ of hearing of one class of fishes, which is not common to all inhabiting the same fluid. Such animals as occasionally pass from the water into the air must have a membrane capable of vibrating in the air; but, even in them, it is expanded under the common integuments, and protected by them. Were it otherwise, when the creature plunged into the water, it would be assailed with that noise (confounding all regular sounds), of which man is sensible when he plunges under water. It appears opposite to the general law of nature to suppose any species of fish to have that delicate membrane which is intended to convey atmospheric sounds; while other creatures living in the water have no such provision.

When we come to examine the ear of the skate, we find, that what Dr. Monro conceives to be the OUTWARD ear of the fish *, is really, as represented by Scarpa, a mucous duct merely †; which does not lead into the sacculi of the vestibule and semicircular canals, as appeared to Dr. Monro; and that to suppose this, would be to acknowledge the free access of air and water to the imme-

* "In the upper and back part of the head of a skate and in a large fish weighing 150 pounds, at the distance nearly of one inch from the articulation of the head, with the first vertebra of the neck or atlas, two orifices capable of admitting small-sized stocking wires, at the distance of about an inch and a quarter from each other, surrounded with a firm membraneous ring, may be observed. These are the beginnings of the Meatus Auditorii Externi." Treatise on the Ear, p. 208.

† Scarpa, speaking of this opinion of Dr. Monro, says, "Qua in re vehementer sibi hallucinatus est, ostia nimirum ductuum mucosorum, ut manifestum est, pro auris meatibus accipiens. Etenim omnino nullum est in cartilagineis piscibus ostium auditus extus adapertum, membranaque *fenestræ ovalis* sub communi integumento recondita jacet et cooperta."

diate seat of the organ, and to the soft pulp of the auditory nerve, a thing not to be believed.* To me it appears, that this narrow duct cannot be considered as the external ear; because we find in the skate a proper membrane under the thin integuments for transmitting the sound quite unconnected with the duct; and, upon following this mucous duct, we find it taking a circuitous course, and filled with a strong gelatinous matter: it is every where narrow, and filled with a glutinous secretion. It has no membrane stretched across it, and bears no resemblance to the external ear of any other animal.

We may conclude, then, that fishes have no external opening like terrestrial animals; that, instead of this outward provision, they have the movable bone within the organ. Although the cartilaginous fishes have a membrane extended over part of the organ, which, in the spinous fishes, is completely surrounded with bone, it is not to be considered as capable of the tremulous motions of the membrana tympani of terrestrial animals, but may be considered as analogous to the membrana fenestræ ovalis; and, since it lies deep under the integuments, we have no reason to believe that sound is transmitted to the organ of hearing in fishes, any otherwise than through the general vibration of the head.

The organ of hearing in amphibious animals demonstrates to us a difference in the manner in which the sensation is received: for they have both the outer membrane to receive the vibration of the air and a mechanism of small bones to convey this motion into the seat of the sense; and they have, besides, within the ear itself, a chalky concretion; a provision plainly intended for propagating the motion communicated through the the water.

In serpents, birds, and quadrupeds, we shall hereafter trace the various gradations in the perfection of this organ. We shall find, that, as the animal rises in the scale, the cavities and tubes of the ear are extended and

* "Quod et absurdum est et a rei veritate quam maxime alienum." Vid. *Anatomicæ Disquisitiones de auditu et olfactu, auctore A. Scarpa.*

varied in their form. Now, I conceive that, while the multiplied forms of the tubes and sphericles of the internal ear afford a more expanded and susceptible surface for receiving impressions, the consonant forms of the parts enable them to receive a stronger vibration, and a more perfect and modified sound.

A chord of a musical instrument will vibrate when another in exact unison with it is struck. The vibration communicated to the air is such as is adapted to the tension of the symphonic chord; and no other percussion of the air, however violent, will cause it to sound. Again, the air passing through a tube of certain dimensions, will not communicate to it a motion, nor call forth its sound, while the air, passing in equal quantity through a tube of one degree of difference, will rise into a full note. What holds true in regard to the unison of chords is also true of cylinders, or even of the walls of a passage or room — a certain note will cause the resonance of the passage or room, as a certain vibration will call forth the sound of the tube of an organ; because it is in all these instances necessary that the impulse be adapted to the position of the surfaces and their powers of reverberation.

These few facts illustrate what I mean, by saying, that the various forms of the internal ear of animals, as they advance in the scale, give additional powers to their organ. In the first example of the simple ear, where a bone vibrates on the expanded nerve, I should conceive that the sensations were in consequence of this simple percussion capable of little variety; but in animals where, besides this simpler mechanism, there are semicircular canals, and more especially in those animals which have still a farther complication of the forms of the ear, certain sounds will be peculiarly felt in each of these several cavities and convolutions; and while the sensation is becoming more distinct, by the perfection of the organ, it admits also of a greater variety of sounds or notes: so that a certain state of vibration will affect the semicircular canals (one or all of them), and produce the sensation of sound, which would not at all affect the vibration of the simple lapilli lying in their sac.

DESCRIPTION OF THE ORGAN OF HEARING IN PARTICULAR ANIMALS.

IN THE LOBSTER AND CRAB.

In these animals, the structure of the ear is very simple; but it appears to me that Professor Scarpa, in his description, has imagined the organ to be more simple than it is in nature.

In the LOBSTER, there projects from near the root of the great antenna an osseous papilla of a peculiarly hard and friable nature. In the point of this papilla we observe a foramen, and a membrane stretched over it. This is the seat of the organ of hearing. It is described as containing a sac of a pellucid fluid, which adheres to the membrane, while the auditory nerve is expanded upon the lower surface of the sac. Now, the lobster, being an animal which can live on land as well as in water, Scarpa gives this as an instance of a structure calculated to receive the sensation of sound equally well from the water or from the atmosphere. But, to me, it does not appear to be so exceedingly simple; while there is evidently a provision for the reception of the vibration communicated through the water, though it does not indeed strictly resemble that which is commonly found in the ears of fishes. There is suspended behind the sacculus, and in contact with the nerve, a small triangular bone, which, when pulled away*, is found to hinge upon a delicate cartilage. This bone seems intended, by its being thus suspended in the neighbourhood of the PULP OF THE AUDITORY NERVE, for impressing upon that nerve the vibration from the water. The lobster, then, has, like the amphibious animals, a double provision for receiving the communication of sound either from the water or from the air.†

The ear of the CRAB differs from that of the lobster in this, that, under the projection, there is a movable case

* See fig. 2.

† From the mucous-like transparency of the nerve in the lobster, it is difficult to ascertain its exact relation to this bone.

of bone, to which we see a small antenna attached. Within this is the organ of hearing; and there is here an internal provision for the transmission of sound to the auditory nerve, which consists simply in a few circumgyrations of a pellucid and flexible cartilage: an inspissated fluid surrounds this cartilage, while the auditory nerve is expanded behind it.

Of the ear of fishes. — In the heads of fishes there is a cavity separated by a thin vascular membrane from that which contains the brain. Within this cavity there is a sacculus distended with a fluid, and containing a small bone*; on the inside of this bag (which is called the sacculus lapillorum) a great proportion of the auditory nerve is expanded. In the cartilaginous fishes there are three lapilli† contained in their proper capsules, and surrounded with a gelatinous matter‡, each of the lapilli having its appropriated division of the acoustic or auditory nerve distributed upon it in a beautiful network.

This cavity in the head of fishes resembles the centre of the labyrinth in the human ear, which is called the vestibule. Within the vestibule there is a limpid fluid, intersected every where by a delicate and transparent cellular membrane; and the parts within the vestibule are supported in their place by this tissue, which is similar to that which supports the brain in fishes.

Besides this central part of the organ in fishes, there are departing from the vestibule three semicircular cartilaginous canals, within which are extended membranous canals. These membranous tubes contain a fluid distinct from that contained in the common cavity of the vestibule, nor have they any communication with the sacculi, which contain the lapilli, although they are in contact with them.§ These cartilaginous canals are

* See plate, fig. 3.

† In many of the spinous or squamous fishes there is only one. In cartilaginous fishes, these bodies are not like bone, but like soft chalk. In the spinous fishes, on the other hand, they are of the shape of the head of a spear, and hard like stone.

‡ The gelatinous matter is rather before the bones, and distending the little sacculi.

§ So Professor Scarpa asserts, in contradiction to others.

of a cylindrical form, and, being as transparent as the fluid with which they are surrounded, are not readily distinguished in dissection. Each of the cartilaginous canals is dilated at one of its extremities into a little belly, which is called the ampulla.

The auditory nerve in cartilaginous fishes* is first divided into two fasciculi, which are again subdivided into lesser nerves. These go to the three sacculi lapillorum, and to the ampullulæ of the semicircular canals. Before the division of the nerve which goes to the sacculus pierces it, it forms a singular and intricate network of filaments. The branch to the ampullula is raised on a partition which stands across as if to receive the undulations of the fluid coming along the tube.

In the spinous fishes, the three semicircular canals unite in a common belly; but in cartilaginous fishes the posterior semicircular canal is distinct from the others.

In fishes all the parts of the ear are filled with a matter of a gelatinous consistence, or viscid fluidity; and the whole sacculi and semicircular canals are surrounded with fluid. That jelly is the most susceptible of vibration, is evident when we fill a glass, and allow a body to fall into it; for then the delicate vibration is communicated to the finger on the outside of the glass, or by striking the glass, we may observe the tremulous motion of the jelly. The semicircular canals, containing such a fluid, are well adapted to receive the extensive vibrations communicated through the bones of the head, and to convey them to the nerve expanded in the ampullula.

From the simpler to the more perfect aquatic animals, we may trace several links of the chain by which nature advances towards the perfect structure of the ear. We return now to observe, in the first example of terrestrial animals, the most simple state of that part of the organ which receives the sensation; but while the structure of the internal organ is the most simple, the mechanism for receiving the vibration and conveying it to the internal ear is modified and adapted to the atmosphere.

* The fifth pair of nerves in fish answers to the seventh in man; has the same division into the *portio mollis* and *dura*.

OF THE EAR IN REPTILES AND AMPHIBIOUS ANIMALS.

In REPTILES, which form the intermediate class of animals betwixt fishes and quadrupeds, the ear has also an intermediate structure: in some individuals of this class the ear resembles that of fishes, such as we have described; while, in others, it resembles more nearly the common structure of terrestrial animals.

In the salamandra aquatica, a variety of the lizard, there is a foramen ovale *, deep under the integuments. In this foramen there is a cartilage, in immediate contact with which there is a common sacculus lying in the cavity or vestibule; and in this little sac there is found a cretaceous matter; there are here, also, semicircular canals, with ampullulæ, and a common belly connecting them. In this animal, then, it is evident, the ear is similar in structure to that of the cartilaginous fishes. †

In the FROG, the outward apparatus is different, but the internal ear is simple. Under the skin of the side of the head, a little behind the prominent eye, we find a large circular opening, which tends inward in a funnel-like form; and from the upper part of the circle of this meatus we find a small elastic bone, or cartilage, suspended. This bone is in contact with the common integuments of the head, which are stretched over the little cavity. This first bone is placed at a right angle with a second bone, and both are lodged in a proper tympanum. ‡ This second bone swells out towards its inner extremity, and is accurately applied to the fora-

* This is the appropriate appellation of the opening, which leads from the outer cavity of the ear, or tympanum, into the seat of the proper organ where the nerve is expanded.

† It is said by naturalists, that the salamander never has been heard to utter a cry; and as dumbness is in general coupled with deafness, it is natural to suppose it has no ears. This is to consider the organ as subservient to conversation.

‡ This tympanum being a cavity containing air, has communication with the mouth by a tube, which we shall afterwards find called Eustachian tube. Several have erroneously described this animal as receiving sounds through the mouth.

men ovale. The foramen ovale opens into a cavity which we must call the vestibule, and which, in this creature, is peculiarly large in proportion to its size. This vestibule contains a sac, upon which the nerve is expanded; it contains also a chalky soft concretion, which is of a beautiful whiteness, and of a regular figure when first seen, but has no solidity. The vestibule here, as in all other animals, being the immediate seat of the sense, is filled with fluid.

In SERPENTS, the mechanism external to the seat of the organ is less complete than in the frog. From the scales behind the articulation of the bone which keeps the lower jaw extended, a little column of bone stretches inward and forward. This bone has its inner extremity enlarged to an oval figure, and is inserted into the foramen ovale. This creature has no membrana tympani, nor does it appear to have so good a substitute as the frog: the outer extremity of the bone seems rather attached to the lower jaw by a cartilaginous appendage and small ligament.* Within the skull, serpents have the little sac, with the cretaceous matter and semicircular canals, united by a common belly.†

In the TURTLE, we find a proper tympanum, and by lifting the scaly integuments from the side of the head a little above the articulation of the lower jaw, we open this cavity. Through this cavity there extends a very long and slender bone, which, upon the outer extremity, is attached by a little elastic brush of fibres to the cartilaginous plate under the integuments, while the inner extremity is enlarged, so as to apply accurately to the foramen, which opens into the vestibule; and a passage also opens from the cavity of the tympanum into the fauces. In this animal, as in all which we have classed under the present division, the internal ear consists of a central cavity, or vestibule, which contains a sac with fluid, and cretaceous matter, and of three

* See Scarpa, tab. v. fig. ix.

† Serpents are affected by music; and they will raise and twist themselves with every variety of lively motion to the pipe and tabor.

semicircular canals connected by a common belly. This common belly of the semicircular canals has no communication with the sacculus vestibuli, which contains the cretaceous matter, further than as it lies in contact with it, and as they both lie surrounded by a fluid: they equally receive the impression of the little bony column, the extremity of which vibrates in the foramen ovale.

There being enumerated forty or more varieties of the LACERTA OR LIZARD, many of these have very different habits. Some of them never pass into the water, but inhabit dry and dusty places. The lacerta agilis, or common green lizard, which is a native both of Europe and of India, is nimble, and basks, during the hot weather, on the trunks of old trees and on dry banks; but on hearing a noise it retreats quickly to its hole. It has the skin over the tympanum extremely thin, and such as to answer precisely the office of the membrane of the tympanum. So all the varieties of reptiles which, in their habits and delicacy of hearing, resemble terrestrial animals, have either the membrane of the tympanum or a skin so delicate as to produce the same effect; while those which inhabit the water have a rough integument, or a hard scale, drawn over the tympanum. Besides this, some have a small muscle attached to the bone, which runs across the tympanum: it is like the tensor tympani, and is another step towards the proper structure of the terrestrial ear.

OF THE EAR IN BIRDS.

Comparing the internal ear of birds with that of the animals which we have already described, we find a very important addition. We find here the internal ear (or labyrinth, as we may now call it,) consisting of three divisions: the vestibule, or middle cavity; the semicircular canals; and the cochlea; which last is an additional part, and one which we have not in the class of animals already described. Leading into these three

cavities, there are two foramina; the FENESTRA ROTUNDA, and the FENESTRA OVALIS; and both these openings have a membrane stretched over them in the fresh state of the parts. The first, the fenestra ovalis, or foramen ovale, receives the ossiculus auditus, which is in birds like that which we have already described in reptiles.* This ossiculus connects the membrana tympani (which is here of a regular form) with the vestibule, and conveys the vibration of the atmosphere to it.

The semicircular canals are here also three in number, and are distinguished by the terms minor, major, and maximus; but as the major and minor coalesce at one of their extremities, and enter the vestibule together, the semicircular canals open into the vestibule by only five foramina in place of six. Each of the semicircular canals is dilated at one extremity into an elliptical form, while the other extremity is of the natural size of the diameter of the tube. These canals are formed of the hard shell of bone, and are surrounded with bone, having wider and more open cancelli.

In the dry state of the parts, we find a cord passing through the semicircular canals, which some have called the ZONULÆ NERVOSÆ. But these are the membranous canals, which are contained within the bony ones, dried and shrunk up. Within the bony cavities of the labyrinth, there is laid a pellucid membrane, which contains a fluid, has the nerves expanded upon it, and is the true vestibule and semicircular canals; while the bony case, which we have described, is merely

* Sir E. Home, in his lecture on the muscularity of the membrana tympani (vid. Phil. Trans. A. 1800), says, in birds this membrane has no tensor muscle to vary its adjustments, but is always kept tense by the pressure of the end of the slender bone. This is a very imperfect account of the mechanism of the tympanum in birds. There are two bones, or one small bone with a cartilage, which lies along the membrana tympani. This elastic cartilage has two little tendons attached to it. Even the slender bone which stretches from the cartilage to the foramen ovale, the inner extremity of which is enlarged to fill up that hole, seems to have a small tendon inserted into it; but whether this be a muscular or ligamentous connection I am unable at present to say.

the mould of these, and the support of their delicate texture.*

The COCHLEA, one of the three divisions of the labyrinth, is but imperfect in birds, when compared with that part of the organ in quadrupeds and in man. The cochlea in birds consists merely of two cylinders, formed of cartilage, which are united toward their further extremity. While the opposite extremities diverge, and while one of these cylinders opens into the vestibule, the other opens outward into the cavity of the tympanum.†

That which, more than any other circumstance, distinguishes the organ of birds from that of animals inhabiting the waters, is the want of the bone or stony concretion in the sacculus vestibuli.

OF THE HUMAN EAR.

THE anatomy of the human ear will naturally be considered under three heads: the external ear; the tympanum; and the labyrinth. The OUTWARD EAR requires no definition. From the outward ear there is a cartilaginous tube, which leads into the tympanum. The TYMPANUM is the cavity within which is placed that mechanism of bones and muscles which increases the strength of the vibration, and conveys it inwards to the labyrinth. The LABYRINTH is the general name of those intricate canals which contain the expanded nerve; it is the proper seat of the sense.

* On drawing out the sacculus vestibuli and semicircular canals from the bony part of the ear of a bird, I find the membranous semicircular canal to consist apparently of the same pellucid elastic matter with those of fishes.

† We find Sir E. Home saying that the cochlea is neither absolutely necessary to fit the organ to be impressed by sounds communicated through the air, nor to render it what is termed a musical ear; and that this is sufficiently proved by that part being wanting in birds, whose organ is particularly adapted to inarticulate sounds. That the cochlea is not necessary to the communication of sound through the atmosphere, we have seen from the examination of the ear of reptiles. But since we see that it forms part of the labyrinth in birds, we may be led to doubt Sir E. Home's conclusion.

OF THE EXTERNAL EAR.

The EXTERNAL EAR is formed of elastic cartilages, covered with very thin integuments. The apparently irregular surfaces of the outer ear will be found, upon examination, to be so formed that the sinuosities lead gradually into each other, and finally terminate in the concha or immediate opening of the tube of the ear. By the constant motion of the external ear of quadrupeds, we see its importance to them both in collecting sound, and in judging of its direction. (We must not forget, however, in estimating the mobility of this apparatus, that the ears are used like the tail, to free them from flies.) In most men, the motion of the ear is lost, but some men still retain it; and this is very remarkable, that when the more internal mechanism of the ear is injured, and ceases to strengthen the sound before it conveys it inwards to the labyrinth, the external ear resumes the office to which it was originally adapted, and, by a degree of motion and erection, assists the hearing. In Europeans, the outward ear is in a great degree flattened to the head by the dress; but in eastern nations, and in ancient statues, we see the ears stand prominent, and bear a part in the symmetry and expression of the whole head. The muscles moving the cartilages, besides being intended to direct the ear, appear to have a more essential use in giving a due tension to the cartilages. These cartilages are surrounded with their peculiar pericondrium; but as to their vessels and nerves, it seems very superfluous to give a minute description of them here.

When the cartilages are dissected they appear thus:

A. The HELIX.—It is the outer margin, the edge of which is turned over, and forms the cavitas innominata.

B C D. The ANTHELIX. — It is very prominent; of a triangular shape; and within the outer rim or margin.

E. The SCAPHA, which is a depression or cavity on the anterior part of the anthelix.

F. The ANTITRAGUS.

G. The TRAGUS. — These are the two prominent points which approach each other, and form the margin of the great cavity of the ear.

L. The CONCHA, or great cavity of the ear, and which is the trumpet-like opening of the meatus auditorius externus. The few pale-coloured fibres which are found on the cartilages are scarcely to be recognised as muscles.*

The LOBE of the ear, or that part which hangs down and is pierced for the ear-ring in women and savages, consists of skin and cellular substance merely.

The MEATUS AUDITORIUS EXTERNUS is the tube which leads into the tympanum. This tube is partly bony and partly cartilaginous. The outer portion of the tube is cartilaginous, and about three quarters of an inch in length, and is divided by fissures. The deeper part of the tube is formed in the bone, as we find upon turning to the description of the temporal bone.

GLANDS OF THE PASSAGE. — The cuticle, covering the inside of the tube, is very fine, and there project from it many small hairs which stand across the passage. Under the skin there is a set of small glands, which pour their secretion into the tube, and are called the GLANDULÆ CERUMINOSÆ.† These glands, secreting the wax of the ear, have their little ducts opening betwixt the roots of the hairs; and this secretion with the hairs which stand across the passage guards the internal parts of the ear from insects. The whole passage, consisting of the canal of the temporal bone and the carti-

* See Valsalva and Santorini.

† "Hæ figuram obtinent variam; major tamen harum pars vel ad ovalem, vel ad sphæricam accedit colore tinguntur flavo ab humore in earum folliculis contento qui ob assiduam fibrarum carnearum reticularium pressionem, per cutis correspondentia foramina in meatus auditorii cavitatem transmittitur." Valsalva de aure humana, p. 10.

laginous tube placed upon it, has an oblique direction. It first passes upward and forward, and then makes a slight curve to descend to the membrane of the tympanum.

This external tube of the ear, being of the nature of a secreting surface, and exposed to the air, is liable to inflammation. There follows a dryness of the passages, and then a more fluid secretion. If the inflammation of the tube should extend within the bones, then, like the affections of all parts surrounded with solid bone, the pain is extreme and the danger considerable: there is not only suppuration in the tympanum and destruction of the membrana tympani, but the disease may be still further communicated internally. Hildanus gives us an observation of the effects of a ball of glass dropt by accident into the ear, in which the inflammation was so extensive, and the pain so excruciating, that the whole side of the head, and even the arm and leg of that side were affected, in consequence of the brain partaking of the inflammation. Such things as peas and cherry-stones and pins are very apt to be put into the ear by children; and awkward attempts to extract the foreign body very often push it further in; and acrid fluids put into the ear to kill insects, have forced them deeper, with such an increase of pain as has thrown the patient into a condition little short of delirium. A defective or too profuse secretion from the glands of the tube will cause a degree of deafness; and sometimes the wax is so indurated as to cause a very obstinate deafness.*

In the fœtus, the concha and meatus externus are

* See Valsalva, p. 10. "Talis surditalis a duodecim annis affligentis curatio." The older writers treat of the "Auditus læsio a surdibus aurium lapidescentibus." See *Bonetus*, and Jul. *Cassertus Placentinus*, "*De auditus organo*," *lib.* I. *cap.* 20. p. 90. There is also mention made of an adventitious membrane closing up the passage, and stretched above the membrana tympani. This is produced by a foul secretion, and resembles that which stuffs up the passage in the fœtus. See Fabricius de Chirurg. operat. cap. de aur. Chirurg. Veslingius Anat. cap. 16. See Experiments on the Solvents of the Ear-wax by Dr. Haygarth, Med. Obs. and Enquiries, vol. iv. p. 198. He gives the preference to warm water over every other solvent.

narrow, and there is secreted a thick white stuff, which defends the membrane of the tympanum from the contact of the waters of the amnios. This, after birth, falls out in pieces along with the secretion of the wax; but, in some instances, it has remained, and become very hard.

OF THE TYMPANUM OR MIDDLE CAVITY OF THE EAR.

THE ANATOMY OF THE TYMPANUM.

In the fœtus, the cavity of the tympanum is superficial, compared with that of the adult; for what forms a tube in the latter, is in the former merely a ring, which is attached to the squamous portion of the temporal bone *: upon this circular bone the membrane of the tympanum is extended.

DESCRIPTION OF THE FIGURE.

The outer ear in outline. The tube of the ear is seen closed at the inner part by the membrane of the tympanum. The chain of bones in the tympanum is seen. And the Eustachian tube leading from the tympanum into the throat.

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* See plate 8. fig. 3.

The tympanum is a very irregular cavity, intermediate betwixt the membrane which is extended across the bottom of the external tube and the labyrinth or internal ear. It contains no fluid, as the labyrinth does; but is really a cavity, having a communication with the external air through a tube which leads into the fauces. The tympanum communicates also backwards with the cells of the mastoid process.* The inner extremity of the meatus externus forms a circle which is pretty regular, and upon which the membrane of the tympanum is extended. That part of the cavity of the tympanum, which is opposite to the termination of the meatus externus, is very irregular. It has in it the foramen rotundum and the foramen ovale; and betwixt these, there is an irregular bony tuberosity, called the tubercle, from which there stretch back some exceedingly small spiculæ of bone, which connect themselves with the margin of the irregular cavity of the mastoid process. On the opposite side of the cavity there is a small eminence, with a perforation in its centre, called the *Pyramid*.

The FORAMEN OVALE† is in the bottom of a deep sinus: it is not strictly of an oval form, but has its lower side straight, while the upper margin has the oval curve. This opening leads into the vestibule or central cavity of the labyrinth.

The FORAMEN ROTUNDUM is more irregular than the oval hole. It does not look directly forward, like it, but enters on the side of an irregular projection: it does not lead into the vestibule, but into one of the scalæ of the cochlea. In the recent state of the parts, the periosteum covering the surface of the cavity of the tympanum takes away something of its irregularity: we trace the internal periosteum backwards into the mastoidean cells.

* When Valsalva, in a case of ulceration and caries on the mastoid process, threw in his injections, he found them flowing out by the mouth; viz. by the Eustachian tube through the tympanum. See Val. de aure humana, p. 89.

† Fenestra ovalis.

The EUSTACHIAN TUBE * extends forward from the cavity of the tympanum, and opens behind the palate.† In the dry bones, the Eustachian tube is more like an accidental fissure, than a regular passage, essential to the economy of the ear. It appears thus irregular in the bones, from the tube being towards the back of the nose, composed of a movable cartilage covered with a soft membrane: as the tube approaches the opening behind the palate, it widens into a trumpet shape; and the extremity of the tube is governed by muscular fibres. Within the cavity of the tympanum, on the upper part of the Eustachian tube, there is a small canal, giving origin to the laxator tympani. This canal has been called *the spoon-like cavity*.

There can be no doubt that the Eustachian tube is designed for admitting the free access of air into the cavity of the tympanum, that, by preserving a due balance betwixt the atmosphere and the air contained within the ear, the motion of the membrane of the tympanum may be free. This, at least, we know, that, when the extremity of the Eustachian tube is closed, we suffer a temporary deafness, which can be accounted for only by the confined air wanting a due degree of elasticity to allow the vibration of the membrane of the tympanum. I conceive it to be necessary, that the air in the tympanum be changed occasionally, which is accomplished by some actions of the throat and fauces, as swallowing, forcing a new body of air into the Eustachian tube. The extremity of the Eustachian tube, next to the throat, may be temporarily obstructed by the cynanche tonsillaris, which is frequently attended with pain, stretching from the throat to the ear; or it may be closed by inflammation and adhesion of its mouth, by adhesion of the soft palate to the back of the fauces, by polypus in the nose, reaching down into the fauces and compressing it, &c. ‡

* Iter a palato ad aurem.

† By some old writers, the Eustachian tube is called aqueduct, because they conceived that humours were evacuated from the tympanum by this passage.

‡ The following case is from Valsalva: — "Quidam plebeius ulcus gerebat supra uvulam in sinistra parte, quod quidam eam, quam

OF THE MEMBRANA TYMPANI.

A. The bony margin of the outer auditory foramen.
B. Membrana tympani.
C. The malleus.
D. The incus.
E. Orbiculare.
F. The stapes.

The membrane of the tympanum is extended over the circular opening of the bottom of the meatus externus. It has a little of an oval shape, and lies over somewhat obliquely, so that its lower margin is further inward than the upper. Its use is, to convey the vibration or oscillation of the atmosphere, collected by the outer ear, inwards to the chain of bones in the tympanum. Although this membrane be tense, it is not stretched uniformly like the parchment of a drum, but is drawn into a funnel-like shape by the adhesion of the long process of the malleus to its centre. It consists of two layers of membrane, and has, naturally, no perforation in it; and the experiments of air, and the smoke of tobacco sent from the mouth through the ear, succeed only in those who have had the membrane of the tympanum partially ruptured or eroded by ulceration. This membrane is transparent; and when we look into the tube of the ear, and direct a strong light into it, we observe it to be of a shining tendinous appearance.

The inner lamina of the membrana tympani is very vascular. It has, indeed, been said to resemble the iris, both in its profusion of vessels, and in the manner of their distribution.* This is carrying the conceit of their analogy too far. I have observed an artery of a

invaserat partem exeserat atque abstuleret sic, ut ulceris cavitas cum extremo sinistræ tubæ orificio communicaret. Igitur quoties homo mollem turundam remediis imbutam in ulceris cavitatem intrudebat: toties illico sinistrâ aure evadebat surdus, talisque permanebat toto ex tempore quo turunda in ulcere relinquebatur," p. 90.

* See Sir E. Home's lecture on the structure and use of the membrana tympani. Phil. Trans. Part I. 1800.

very large size (compared with the surface to be supplied) running by the side of the long process or handle of the malleus. In this course, it is giving out small branches; and when the trunk arrives at the extreme point of the long process of the malleus, it divides into two branches, the extreme subdivisions of which run towards the margin of the membrane. This artery is, nevertheless, too small to require us particularly to avoid it in the puncturing of the membrane for deafness, produced by obstruction of the Eustachian tube.

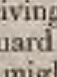
The opinions regarding the muscularity of the membrane of the tympanum shall be reserved until we have considered the whole mechanism of the parts in the tympanum.

OF THE CHAIN OF BONES IN THE TYMPANUM.


Malleus.


Incus.


Orbiculare.


Stapes.

The vibrations of the membrane of the tympanum are transmitted to the foramen ovale by four movable bones, — the malleus, incus, os orbiculare, and stapes. These bones are named from their shape, and the names assist in conveying an idea of their form. They are so united, by articulation and small ligaments, as to form an uninterrupted chain; and, while they transmit the vibration, their mechanism is such, that they strengthen the impulse. They have also small muscles attached to them, by which, it is probable, the whole apparatus has a power of adapting the degree of tension to the force of the impulse communicated to the membrane of the tympanum. I conceive that they increase the power of the ear for receiving the weaker sounds, and are, at the same time, a guard to the internal parts, from such violent shocks as might injure the nerve.

How necessary it sometimes is to damp and suffocate, in some degree, piercing sounds, we must all be sensible; and in those who are habitually exposed to the sudden eruption of sound, the susceptibility of the nerve is injured, and they become very deaf. We have, in a late publication, an example of this in blacksmiths, in whom it is common to find a degree of deafness; and we find old artillery-men quite deaf, from the long practice of their profession.

The MALLEUS receives its name from a resemblance to a hammer or mallet: it is, in some degree, like a bludgeon; the great head stands obliquely off from the body of the bone (if such it may be called) like the head of the thigh-bone. Anatomists can scarcely be blamed, if, in describing the processes of this bone, they forget the body. I should consider that part as the body of the bone which stretches down from the circular margin of the tympanum, and is attached to the membrane, or what we should consider as the handle of the mallet. This part of the bone stands at an angle with the head and neck; tapers towards the extremity, and is a little curved down towards the membrane. From the larger end of the body of the bone there stands out an acute process; and from the neck attaching the bulbous head to the body of the bone there stands out a very slender process, which is often broken off. The great head of the bone does not form a regular ball to be socketed in the body of the incus: there are irregularities in the contiguous surfaces of both the bones.*

The INCUS is the second bone of the chain: it receives its name from its resemblance to the blacksmith's anvil. It more resembles a molar tooth with two roots. On the surface of the body, it has a depression like the surface of the first molaris. Into this depression of the incus the head of the malleus is received. The shorter of the two processes and the body of the bone lie on the margin of the circular opening of the tympanum; and the acute point of this process is turned back into the opening of the mastoid cells. The long leg or pro-

* See plate 2. fig. 1. A.

cess of the incus hangs down free into the tympanum*, and has attached to its point the os orbiculare.

The OS ORBICULARE or lenticular bone is like a grain of sand in size, and is the smallest bone of the body: it is a medium of articulation betwixt the incus and stapes; and were it to be magnified, it would resemble the body of a vertebra.†

The STAPES‡ or stirrup is well named, for it has a very close resemblance to a stirrup-iron; the little head is articulated with the os orbiculare; the arch of the bone is exactly like that of the stirrup-iron, but elegantly grooved within, so as to give lightness to the bone. It has a membrane stretched across it. The base answering to that part of the stirrup-iron upon which the foot rests is not perforated, nor is it of a regular form, but is flat on one side, corresponding with the foramen ovale. It is this base of the bone which is attached to the membrane stretched over the foramen ovale.

CONNECTION AND MOTION OF THESE BONES.

The malleus, hanging on that part which we have called the neck of the bone, has the long handle or body of the bone stretched down upon the membrane of the tympanum. It is destined to receive the oscillations of that membrane.

The head of the malleus is so articulated with the incus, that the degree of motion communicated to that bone is much increased.

* See plate 2. fig. 1. B.

† Soemmerring supposes he has disproved the existence of this bone. See plate 2. fig. 1. D.

‡ See plate 2. fig. 1. C.

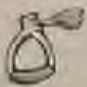
From this scheme, we see, that the head of the malleus is so articulated with the body of the incus, that the centre of motion of the incus is in a line drawn through the centre of its body, and, consequently, that the extremity of the long process, to which we see the os orbiculare and stapes attached, moves through a greater space than that which receives the impulse of the head of the malleus. Thus, a very small degree of motion communicated by the head of the malleus to the body of the incus must be greatly increased in the extremity of the long process of the incus, and, consequently, this mechanism of the bones essentially assists in giving strength to the vibration which is transmitted inward to the seat of the nerve.

The os orbiculare stands simply as a link of communication betwixt the extremity of the incus and the upper part of the stapes, and its use is evidently to promote the accurate and perpendicular motion of this long lever of the incus upon the head of the stapes; for, if this bone had not been so placed, the motion of the long lever of the incus must have given an obliquity to the impulse upon the stapes. The base of the stapes almost completely fills up the foramen ovale. It is seated on a membrane which is stretched over the foramen.* The stapes, then, acts like a piston on a membrane of much less circumference than that of the membrana tympani. From all which considerations, we may learn how much the vibration produced by the agitation of the air in the outer canal of the ear is increased, before it strikes upon the fluids of the labyrinth.

* Valsalva has the following observation, see page 24.: "Olim namque in cujusdam surdi cadavere surditatis causam in eo sitam inveni nempe quod indicata membrana in substantiam osseam indurata, unum continuatum os constituebat cum basi stapedis et margine fenestræ ovalis."

OF THE MUSCLES WITHIN THE TYMPANUM.*

A. Laxator tympani.
B. Externus mallei.
C. Tensor tympani.



Stapedius.

The laxator tympani arises from the upper part of the edge of the tympanum, near the part to which the membrane of the tympanum adheres, and is inserted into the handle of the malleus, near the root of its shorter process. The TENSOR TYMPANI† arises from the upper part of the Eustachian tube; it lies along the side of the tube, and is inserted into the handle of the malleus below the slender process. The external or superior‡ muscle of the malleus, which is denied by some anatomists to be of the nature of muscle, comes from the fore and upper part of the tympanum, and is fixed by a small tendon to the processus gracilis of the malleus.

The STAPEDIUS § is the smallest muscle, and is attached to the smallest bone. It has a small round fleshy belly, taking its origin from the pyramid, and is inserted by a small round tendon into the head of the stapes.

As all these muscles are inserted either into the malleus or stapes, and not into the middle bones, it would appear that their operation is chiefly upon the membranes of the tympanum, and of the foramen ovale, through the medium of the bones immediately attached to them.

Sir E. Home, in the Philosophical Transactions for

* Musculus processus minimi mallei. Valsalva.
† Musculus processus majoris mallei.
‡ Musculus processus minoris. Valsalva.
§ This muscle is particularly strong in the horse, where it was first discovered by Casserius.

1800, asserts, that the membrana tympani is muscular; that its fibres run from the circumference towards the centre; and that they are attached to the malleus.

But what is the supposed use of this muscular membrane? Sir E. Home says, it is principally by means of this muscle that accurate perceptions of sound are communicated to the internal organ; that it is by means of this muscle that the membrana tympani is enabled to vary its degree of tension, so as to receive the vibrations in the quick succession in which they are conveyed to it. But we have seen, that the tension and relaxation of the membrana tympani is already sufficiently provided for: "the malleus has three muscles by which it is moved; one of them is called the tensor, from its pulling the malleus inward, and tightening the membrane of the tympanum; the other two act in an opposite direction, and relax the membrane."* We should naturally suppose this to be sufficient; but, according to Sir E. Home, these muscles act only to bring the membrane into such a degree of tension, as to enable the minuter changes of the muscular membrane to have their full effect; and that the play of these muscles gives the perception of grave and acute tones.

But the more favourite idea of Sir E. Home is, that, upon the accurate adjustment of the membrana tympani, the difference between a musical ear, and one which is too imperfect to distinguish the different notes in music, depends; that this judgment or taste is owing to the greater or less degree of nicety with which the muscles of the malleus render the muscular membrane capable of being truly adjusted; if the tension be perfect, all the vibrations produced by the action of the radiated muscle will be equally correct, and the ear truly musical.

Sir E. Home proceeds upon the idea, that the membrane of the tympanum is like a musical instrument, or, as he expresses himself, like a monochord; but he is fundamentally wrong in supposing, that it requires a more delicate organ to be perceptible of musical tones than of articulate sounds or language. In the first

* Sir E. Home's Lecture.

place, we may require an explanation of the use of that muscle which is inserted into the stapes. This stapedius muscle would seem to have the same use, and to affect that bone in the same manner, in which the muscles of the malleus affect it. Surely Sir E. Home will not go so far as to say, that the membrana fenestræ ovalis is also muscular. It may be further worthy of attention, in considering this subject, that whatever affects the membrane of the tympanum, affects, also, the membrane of the vestibule.

In the paper already quoted, the following case is given, as illustrating the manner in which the loss of the natural action of the muscles affects the ear, in regard to its capacity for music. A gentleman, thirty-three years of age, who possessed a very correct ear, so as to be capable of singing in concert, though he had never learned music, was suddenly seized with a giddiness in the head, and a slight degree of numbness in the right side and arm. These feelings went off in a few hours, but on the third day returned; and for several weeks he had returns of the same sensations. It was soon discovered that he had lost his musical ear; he could neither sing a note in tune, nor in the smallest degree perceive harmony in the performance of others. For some time, he himself thought he had become a little deaf, but his medical attendant was not sensible of this in conversation. Upon going into the country, he derived great benefit from exercise and sea-bathing.

In this case, continues Sir E. Home, there appeared to be some affection of the brain, which had diminished the action of the tensor muscles of the membrana tympani, through the medium of the nerve which regulates their actions; this gradually went off, and they recovered their action.

Another case is given of a young lady who was seized with a frenzy which lasted several years, when, from being without a musical ear, she came to sing with tolerable correctness, to the astonishment of her friends.

We now proceed to put the incorrectness of this reasoning, concerning the muscular power of the membrane of the tympanum, in a more particular point of

view, leaving to Sir E. Home's paper only the merit of ingenuity. Sir A. Cooper was led to pay particular attention to the action of the membrane of the tympanum, from being consulted in a case where the membrane was lost, with little injury to the function of the organ.* He found, that, instead of the total annihilation of the powers of the organ, the gentleman was capable of hearing whatever was said in company, although the membrane of both ears was destroyed. He could even hear better in the ear in which no traces of the membrane remained. This gentleman was only in a sl degree deaf from the loss of the membrane; but his ear remained nicely susceptible of musical tones, "for he played well on the flute, and had frequently borne a part in a concert; and he sung with much taste and perfectly in tune." This case puts aside, at once, that theory which supposes the musical ear to depend on the minute play of the muscles of the tympanum.

It appears, from these and other instances, that the membrane of the tympanum may be destroyed, that the

* Case.—This gentleman had been attacked, at the age of ten years, with an inflammation and suppuration in his left ear, which continued discharging matter for several weeks: in the space of about twelve months after the first attack, symptoms of a similar kind took place in the right ear, from which matter issued for a considerable time. The discharge, in each instance, was thin, and extremely offensive to the smell; and in the matter, bones, or pieces of bones, were observable. The immediate consequence of these attacks was a total deafness, which continued for three months: the hearing then began to return; and, in about ten months from the last attack, was restored to the state in which it at present remains. Having filled his mouth with air, he closed the nostrils, and contracted the cheeks; the air thus compressed, was heard to rush through the meatus auditorius with a whistling noise, and the hair hanging from the temples became agitated by the current of air which issued from the ear. When a candle was applied, the flame was agitated in a similar manner.

Sir. A. Cooper then passed a probe into each ear, and he thought the membrane on the left side was entirely destroyed, since the probe struck against the petrous portion of the temporal bone. The space usually occupied by the membrana tympani was found to be an aperture without one trace of membrane remaining. On the right side, also, a probe could be passed into the cavity of the tympanum; but here, by producing it along the sides of the meatus, some remains of the circumference of the membrane could be discovered, with a circular opening in the centre about the fourth of an inch in diameter. See Trans. Roy. Soc. for 1800. Part I. p. 151.

bones may be washed out by matter formed in the tympanum, and still the patient retain the use of the organ. But this is only while the stapes retains its place; for if this bone be destroyed, the membrane of the foramen ovale will be destroyed, and the fluids of the labyrinth be allowed to flow out, or be otherwise lost. We see that, if the chain of bones, and only a part of the membrana tympani be left, still this shred of membrane, if it be not detached from the handle of the malleus, will vibrate in the air, and communicate those motions through the other bones to the vestibule. We see, also, that though the bones only remain, and though they be detached from the membrane of the tympanum, the sound will still be communicated. We see, that a rupture of the membrane will not destroy the organization so far as to prevent the hearing, unless there follow clots of blood or inflammation, suppuration, or fungus. When Sir A. Cooper found that the membrana tympani could be torn without injuring the organ, he did not stop short in his investigation: but as he found, by daily experience, that obstruction of the Eustachian tube caused deafness, he thought of puncturing the membrana tympani, as a cure for that kind of deafness. He expected, by this operation, to give elasticity to the confined air. Accordingly, by puncturing the membrane of the tympanum with a small trocar, he found, with much satisfaction, that the hearing was instantly restored.*

Valsalva made a good distinction, when he said, that the membrane of the tympanum was not absolutely necessary to hearing, but only to perfect hearing. We have, in this fact, the explanation of the following circumstance, amongst many others: "In naturali surditate a conformationis vitio inter tandem istud experi-

* I am only afraid that such punctures will not continue open, as in Valsalva's experiments they healed up very soon. But, when there is no other ingress and escape to the air in the tympanum but through the punctured hole, it may tend to keep it open. See much of this in Morgagni, Epist. An. XII. The membrana tympani is very vascular. I have it red with injection. See Ruysch. fig. 9. tab. 9. Epist. An. VIII.

mentum (viz. an ossiculi et membrana tympani aliquis sit usus auditum), quod inopinato et feliciter successit cuidam, qui intruso auri scalpio in aurem profundissime disrupit tympanum, fregitque ossicula et audivit."* Willis also knew, that the destruction of the membrana tympani did not deprive the person of hearing. *Vid. de Anima Brutorum.* A most ingenious paper is given to the Philosophical Transactions, by Dr. Wollaston, in which it is shown that the exterior apparatus of the ear, and especially the parts in the cavity of the tympanum, are intended to give us the perception of acute and delicate sounds.

OF THE DISEASES OF THE TYMPANUM.

Valsalva denied the existence of periosteum to these bones of the tympanum, while he allowed that they had minute vessels distributed on their surfaces: but these vessels he supposed to creep along the naked bone indepently of any membrane. This, however, is contrary to all analogy.† These bones, as well as the cavity of the tympanum, are covered with a very fine membrane or periosteum, which, after a minute injection, is seen covered with many small and distinct vessels, as well as with intermediate extravascular effusions of the injection, as happens in injecting in other membranes.

When the tympanum becomes diseased, there is fetid matter collected, the membrane of the tympanum suffers, and the small bones are sometimes discharged. In such a case we have little farther to do than, by injections, to prevent the matter from accumulating. But let us not confound this serious cause of deafness with the slighter suppurations in the outer passage of the tube; although such suppurations in the tube of the ear are apt, when neglected, to destroy the membrane of the drum or tympanum, and to spread disease to these internal parts.

Authors make a display of the diseases of the mem-

* Riolanus Enchirid. Anat. lib. 4. c. 4. See also Bonetus de Aurium Affect. Observ. IV.

† See Ruysch. Epist. Anat. VIII. tab. 9.

brane of the tympanum under the titles relaxatio, tensio nimia, induratio, and diruptio tympani.* We have seen how little rupture of the membrane affects the hearing, and may thence conclude, that these fantastic opinions about tension and relaxation of the membrane deserve little notice. The idea of relaxation of the membrane of the tympanum, I have no doubt, has arisen from the effect of cold and moist weather in injuring the hearing; but deafness from this cause is not produced by relaxation of the membrane of the tympanum, but by swelling of the mouth of the Eustachian tube.†

Induration of the membrane is less of an imaginary disease, since there are instances of the membrane becoming thickened by inflammation, or cartilaginous, or osseous. The membrana tympani has been found to adhere to the extremity of the incus.‡ Independently of the want of elasticity, which such an adhesion must produce, the vibration of the bones is prevented, and a degree of deafness is inevitable.

Fungous or polypous excrescences from the glands in the outer passage of the ear press back and destroy the membrane of the tympanum. In the cure of these by the knife, caustic, or ligature, there is much danger of injuring the membrane. Fungous tumours project from the membrane itself. A stroke upon the head will cause bleeding from the ear. This is often a sign of concussion of the brain; that is to say, a shock so severe as to rupture the membrane of the tympanum, will most probably injure the brain.§ After bleeding from the ear,

* See Du Verney de Organo Auditus, p. 41.

† "Relaxatio fit ab humore superfluo qui membranam hanc humectat et symptoma hoc communiter cum obstructione meatus ex tumore glandularum conjunctum est, de qua jam supra dictum est: multum autem facit ad difficultatem audiendi in personis quæ defluxionibus catarrhosis obnoxiæ sunt et per eandem rationem austri nebulæ et aer pluvius auditum minuunt ut experiri quotidie possumus." *Du Verney*, loc. cit. p. 41.

‡ See the London Philosophical Transactions for 1800, Part I. p. 5.

§ When Valsalva found the ventricles of the brain full of blood, and blood also in the tympanum, he supposed that the blood in the latter was derived from the brain through certain foramina which he discovered. See p. 30.

sometimes suppuration follows *; and blood flowing thus from the membrane of the tympanum, or other part of the ear, runs back into the cavity of the tympanum, and, filling it with coagulum, causes deafness, by obstructing the free motion of the bones and membrane. Sir A. Cooper, in a case of this kind, punctured the membrane, and, after a discharge of blood which continued for ten days, the hearing was gradually restored. It is supposed by that gentleman, that the blood effused becomes, in some instances, organized, so as to obliterate the tympanum, causing permanent deafness.

The danger in suppuration and caries of the tympanum is that the disease may penetrate backward into the mastoid cells and labyrinth, or into the brain itself; for inflammation and suppuration so confined amongst the deep recesses of the bone must give great torture, and be apt to extend the mischief to the brain; or the bone becoming carious, matter may be thrown out on the inside of the cranium, the effect of which must be mortal. Such I have seen to be the effect of suppuration deep in the ear. In a man who had been deaf for many years, and who was killed suddenly by a fracture of the skull, I found the cells of the temporal bones filled with matter, and a thin greenish fluid lay betwixt the temporal bone and dura mater. I have since found the caries of the petrous bone from this cause fatal in young people.

Valsalva gives us a case of injury of the head, in which the patient was relieved while the discharge of pus by the ear was free; but he died when it was entirely suppressed.†

But, after such suppuration as we should naturally think must totally destroy so delicate an organization, we are sometimes agreeably surprised with a gradual

* See Valsalva, p. 16.

† Valsalva, p. 83. See also a case in Bonetus de Aurium Affect. Observ. I. and Gul. Ballonius Epid. et Ephem. lib. 2. p. 270. When the matter was suppressed, there came pain of the head, and weight, which yielded to no remedy: on dissection, there was found an abscess within the skull. In Bonetus, loc. cit., a case is related, in which an ignorant surgeon compressed a fistulous ulcer in the ear, and so caused the death of the patient.

recovery of the function. This is owing to the nerve accommodating itself or becoming sensible to a less forcible impression, and by the ear acquiring new properties. I have already mentioned that the destruction of the mechanism of the tympanum arose sometimes from suppurations beginning in the outward ear; and we may suppose that the apparatus within the tympanum, when partially hurt, is sometimes capable of being, in some degree, replaced by a natural process; of which the following case from Valsalva is a remarkable proof:—

"I lately examined the ears of a woman whose hearing had been much injured by an ulcer of the tympanum and caries of the small bone. I found the ear in which she was deaf without a membrana tympani, and the stapes only remaining of the bones, and a fibrous mass, like an excrescence, in the tympanum. But, in the tympanum of the opposite ear, I found the membrana tympani almost entirely eroded; so that the malleus and incus were uncovered, and distinctly seen. I could even observe, that the long process of the incus, which should be articulated with the head of the stapes, was separated from it: but nature had curiously restored the eroded membrane. Thus, from the edge of the injured membrane, a new membrana tympani was obliquely stretched across the cavity of the tympanum, so as to exclude the malleus and incus from that cavity, but including the head of the stapes, as if nature, finding the separated bones no longer necessary, had attached the membrane to the head of the stapes."* We have already remarked, that, when the organ of one side is injured, we hear so much better with the other, that we attend only to the sensation conveyed by it, and neglect the duller sensation. The consequence of this is, that the bad ear becomes worse. It is much like that effect which takes place in eyes by squinting.

* See Valsalva de Aure Humana, Tract. p. 79. In those deaf from birth it has been twice found that the *incus* was wanting. See Bonetus de Aur. Affect. Observ. IV.

OF THE LABYRINTH.

DESCRIPTION OF THE FIGURE.

The labyrinth first cut out of the solid bone, and then opened so as to show the cavities. The central one, the vestibule; the semicircular canals; and the cochlea, so laid open as to exhibit part of the scala vestibuli and scala tympani. The chain of bones is attached, the stapes resting on the foramen ovale.

The labyrinth is the internal ear; the proper seat of the sense of hearing. It consists of the vestibule or middle cavity of the semicircular canals; and of the cochlea. It has its name from those cavities and tubes leading into each other in so intricate a manner, as to be followed out with much difficulty.

We understand that the cavities hitherto described in the human ear contain air, and communicate with the atmosphere: but, in the cavities we have now to describe, the nerve is expanded, and there is, in contact with it, not air, but an aqueous fluid. In treating of this division of our subject, we have, first, to attend to the forms of the cavities, as seen when sections are made in the dry bones next to the soft parts contained in those cavities; and, finally, to the distribution of the nerves. To give an idea of the exquisitely delicate and complex structure of the many canals, excavations, openings, sulci, and foveæ, of the bones; of the tubuli, sacculi, and partitions of the membranes; and, lastly, of the soft expansions of the nerves, without the assistance of plates, would be impossible. Albinus, in his academical annotations, begins very formally a chapter on the ear; but, after a few words, dismisses the subject, referring merely to his plates.

The VESTIBULE, or central cavity of the labyrinth, is of an oval form, and about a line and a half in diameter.*

* Du Verney Œuvres Anatomiques.

It has two remarkable pits or hollows in it, and has numerous foramina opening from it into the neighbouring cavities, besides lesser foramina for transmitting that portion of the nerve which is distributed on the sacs contained in it. One depression or fovea is in the back or or lower part of the vestibule, another in the outer and superior part of it: the one is circular, the other semi-oval. Morgagni, and other anatomists, examining the dry bones, speculated on their use in reverberating the sound in the cavity; but we must not regard them in this unnatural state: on the contrary, they contain in the living subjects membranous sacculi filled with fluid, in which membranes the nerve is finally distributed. That foramen over which the stapes is placed, and which is called the foramen ovale, transmits the vibration into the vestibule. For the foramen ovale opens directly into the vestibule, and through the vestibule, only, does the vibration of the bones in the tympanum reach the other parts of the labyrinth.

Semicircular canals.—When we have cut into the vestibule, by taking away that portion of the os petrosum which is behind the meatus auditorius internus, we see five circular foramina: these are the openings of the semicircular canals. There are three semicircular canals; and they are distinguished by the terms, the superior or vertical, the posterior or oblique, and the exterior or horizontal. The one which, in this view, is nearest, is the opening common to the inner ends of the posterior and superior semicircular canals. When we pass a bristle into this common foramen, and direct it upward, it passes along the superior semicircular canal, and will be seen to descend from the upper part or roof of the vestibule, almost perpendicularly on the foramen ovale, which is open, and immediately opposite. If, again, we pass a bristle into the foramen which is near the bottom of the cavity, (and which will be just upon the edge of the fracture that has laid open the vestibule, if not included in it,) it will come out by the opening common to the superior and posterior semicircular canal. It has passed, then, along the posterior canal. The two openings of the exterior or horizontal canal are upon the back part

of the vestibule; and the canal itself takes a circle which brings its convexity to the confines of the mastoid cells. These canals are formed of a very hard brittle bone; their calibre is so small as not to admit the head of a common pin; they form somewhat more than a half circle; and of each of them, one of the extremities is enlarged like the ampullula of fishes. Valsalva imagined that the enlarged extremities of these tubes were trumpet-like, to concentrate and strengthen weak sounds. We shall find, on the contrary, that there is in the human ear, as in fishes, a particular expansion of the nerve in these extremities of the tube, opposed to the circulatory vibration of the fluids in the canals.

The COCHLEA.—The third division of the labyrinth is the cochlea. It is so named from its resemblance to the shell of a snail, or from the manner in which its spiral lamina turns round a centre like a hanging stair. It has been minutely, but not simply, described; and, indeed, there can be nothing more difficult than to describe it in words.

When the os petrosum is cut from around the cochlea, it is seen to be of a pyramidal shape, and to consist of a scroll, making large circles at the base, and gradually lesser ones towards the apex. It is formed in the most anterior part of the petrous bone, and has its apex turned a little downward and outward; and the base is opposed to the great cul de sac of the internal meatus auditorius.

The spiral tube, of which the cochlea is composed, forms two turns and a half from the basis to the point; and it consists of the same hard and brittle matter with the semicircular canals. When the whole cochlea is cut perpendicularly in the dry state of the bones, and when the membranes have shrunk away or spoiled, the sides of the spiral canal appear like partitions, and are, indeed, generally described as such. In consequence of the spiral tube of the cochlea having its sides cut perpendicularly as in this figure, the cochlea appears as if divided into three circular compartments or successive stages; but there is really no such division; because the spiral turnings of the tube lead from the one into the other.

What gives particular intricacy to the structure of this part of the labyrinth is the LAMINA SPIRALIS.* This spiral partition runs in the spiral tube of the cochlea, so as to divide it in its whole length; and, in the fresh state of the parts, this lamina of bone is eked out by membrane, so as to form two perfectly distinct tubes. These tubes are the SCALÆ COCHLEÆ; they run into each other, or communicate at the apex of the cochlea; but at the base, the one turns into the vestibule, and the other opens into the tympanum by the FORAMEN ROTUNDUM.

In the middle of the cochlea there runs down a pillar, which is the centre of the circumvolutions of the scalæ. It is called the MODIOLUS. This pillar is of a spongy structure; and through it the nerves are transmitted to the lamina spiralis.

The modiolus opens towards the apex of the cochlea like a funnel; and when we take away the outward shell of the apex of the cochlea, which is called the CUPOLA, we look into this expansion of the upper part of the modiolus as into a funnel; it is therefore called the INFUNDIBULUM. The infundibulum is that part which, in a perpendicular section, we should call the upper partition D.†

The scalæ, or divisions of the spiral tube of the cochlea, have a communication at their smaller extremities in the infundibulum; and as, again, their larger extremities do not open into the same cavity, but one into the vestibule, and the other into the tympanum, the vibrating motion, which is communicated through the cochlea, must pass either from the tympanum into the foramen rotundum, circulate round the modiolus by the scala tympani, pass into the lesser extremity of the scala

* A, Lamina spiralis. B, Scala vestibuli. C C, Scala tympani. D, The hook of the lamina spiralis in the infundibulum.

† That is, supposing the cochlea to rest on its base, which it does not.

vestibuli in the infundibulum, and circulate through it towards the base of the cochlea, until it pass into the vestibule; or it must pass from the scala vestibuli into the scala tympani. The first is the opinion of Scarpa and others. But I trust it will afterwards appear, that the oscillations of sound are in the first place conveyed into the vestibule, and thence circulate round both the semicircular canals and cochlea.

In the dry bones, when we cut into the cochlea, there appears a spiral tube, as I have described, with a partition running along it, and, of course, taking the same spiral turns with it towards the apex. This is the bony part of the lamina spiralis; but, as the membrane which extends from its circular edge quite across the spiral tube of the cochlea has shrunk and fallen away in the dry state of the parts, the lamina spiralis is like a hanging stair, and the scalæ are not divided into distinct passages. In this bare state of the shell of the cochlea, when we cut away the cupola or apex of the cochlea, and look down upon the infundibulum, we see the extreme point of the lamina spiralis rising in an acute hook-like point.

The modiolus or central pillar, and the lamina spiralis which encircles it, are of the most exquisite and delicate structure; for through them the portion of the seventh nerve destined to the cochlea is conveyed. To say that the modiolus is formed of two central bones, is saying that there is no central column at all; or that the modiolus is the cavity seen in the bottom of the meatus auditorius; and to affirm, at the same time, that the modiolus is a nucleus, axis, or central pillar, is a contradiction in terms.

When we break away the shell of the cochlea, and break off also the spiral lamina, we find the little funnel-like depression in the bottom of the meatus internus, reaching but a little way up into the centre of the cochlea. — We find this depression of the meatus auditorius internus perforated with innumerable small holes; and these foramina are so placed as to trace a spiral line, because they give passage to the nerves going to the spiral lamina, and must take the form of the dimin-

ishing gyrations of the lamina spiralis. In the centre of these lesser foramina, which are seen in the bottom of the great foramen auditorium internum, there is a hole of comparatively large size, which passes up through the middle of the pillar. The modiolus is formed of a loose spongy texture, and resembles the turns of a cork-screw; and this spiral direction is a necessary consequence of the lamina spiralis, being a continuation of the spongy or cribriform texture of the modiolus.

INTERNAL PERIOSTEUM OF THE LABYRINTH. — We find that the vestibule, the semicircular canals, and cochlea, besides their soft contents, which we have yet to describe, have their proper periosteum, which, after a minute injection, appears vascular; and this, as it has appeared to me, is particularly the case with the last-mentioned division of the labyrinth. I see very considerable vessels distributed on the vestibule; particularly, I see their minute ramifications on the circular fovea, while very considerable branches are seen to course along the semicircular canals. In the cochlea, I see distinct branches of vessels rising from the root of the lamina spiralis, and arching on the scalæ, to the number of ten in the circle; and, after a more minute injection, I have found the osseous part of the lamina spiralis tinged red, and the membraneous part of a deep scarlet.*

We have observed the MEATUS AUDITORIUS INTERNUS to be a large oval foramen in the posterior surface of the pars petrosa of the temporal bone. This tube transmits the seventh or auditory nerve. It is about five lines in diameter, but increases as it passes inward; and appears to terminate in two deep foveæ, which are divided by an acute spine. But the auditory foramen only appears to terminate in these foveæ, for they are each perforated by lesser holes, which lead into the three divisions of the labyrinth, whilst a larger one conveys a portion of the nerve through the cavities of the

* In a preparation before me, I see a considerable artery derived from the basilar artery, entering the meatus auditorius internus. From this trunk, I conceive that most of these arteries which I have described are derived.

temporal bone altogether, and out upon the side of the face. This larger foramen is in the upper part of the superior and lesser fovea. It first ascends to near the surface of the petrous part of the temporal bone *, and then descends and turns backward, and takes a course round the tympanum above the foramen ovale, and close by the posterior semicircular canal. Its termination is the foramen stylo-mastoideum. † Where this canal of the portio dura advances towards the surface of the pars petrosa, it is joined by a very small canal which extends from the videan hole on the fore part of the inclining face of the bone: again, after it has passed the tympanum, it is joined by a short canal which receives the corda tympani, after it has passed the tympanum.

The other foramen which is in the upper and lesser fovea of the meatus internus is rather a cribriform plate, as it is a deep pit with many foramina in it. These lead into the vestibule, and form the MACULA CRIBROSA VESTIBULI. ‡ In the inferior and larger fovea, we observe several dark spots, which, when more narrowly examined, are also distinguished to be cribriform plates, or collections of lesser foramina. We particularly observe that conical cavity which is perforated with many little pores for transmitting the nerve into the cochlea, and which we have already mentioned. From the form which these foramina take, this is named the TRACTUS SPIRALIS FORAMINOLOSUS. These foramina, after passing along the modiolus cochleæ, turn at right angles, and pass betwixt the plates of the lamina spiralis.

Besides the tractus spiralis foraminolosus the bottom of the larger fovea has many irregular foramina, which are like cancelli: for very delicate spiculæ of bone stand across some of them. There is a range of these foramina which stretches from the tractus spiralis. This may properly be called the TRACTUS CALTHRATUS RECTUS §; they do not lead into the vestibule, but into the beginning of the lamina spiralis, where it divides the

* In the fœtus, it becomes here superficial.
† This is the aqueduct of Fallopius.
‡ See Scarpa, Plate VII. fig. i. m.
§ Tractus spiralis foraminolosi initium. *Scarpa.*

two scalæ cochleæ, and turns the orifice of one of them (by a beautiful curve) out into the tympanum.

Nearer to the ridge which divides the two foveæ of the meatus internus, there is a little pit which has also a cribriform plate (like that which is in the upper fovea, and is called macula cribrosa); opposite to this point the inside of the vestibule is rough and spongy: it transmits a portion of the nerve to the sacculus in the hemispherical sinus of the vestibule.*

OF THE SOFT PARTS CONTAINED IN THE LABYRINTH.

Within the vestibule, semicircular canals, and cochlea, there are soft membranes independent of the periosteum. These form sacculi and tubes which contain a fluid, and have the extreme branches of the portio mollis distributed among them. Betwixt the soft and organised sacculi and tubes and the periosteum of the osseous labyrinth a watery fluid is exuded.

Sacculus vestibuli.—The hemispherical and semi-elliptical foveæ which we have described in the vestibule contain, or at least receive partially, two sacculi. The sacculus which is in the hemispherical cavity receives the most convex part of the sacculus vestibuli. This sac is distended with a fluid, and is pellucid, and fills the greater part of the vestibule; for only a part of it is received into the fovea. It forms a complete sac, and has no communication with the other soft parts of the labyrinth, though lying in contact with the alveus communis, presently to be mentioned; and being surrounded with an aqueous fluid, it must receive the impressions of sound in common with them.

Alveus communis ductuum semicircularum.—This sacculus lies in the semi-elliptical fovea of the vestibule, or like the other sacculis, is in part received into it. This sacculus receives the extremities of the tubuli membranacei which lie in the semicircular canals; it is a little bag common to them, and connecting them altogether, as in fishes; it is filled with fluid, and is so

* Scarpa.

pellucid, as to be distinguished with much difficulty. Upon pressing the common sac, or the ampullulæ of the semicircular canals, the fluids are seen to circulate along the membranous tubes of the canals. These two sacculi in the vestibule lie together, and firmly adhere, but do not communicate; yet (as may be easily imagined) they cannot be separated without tearing the partition.

Tubuli membranacei.—The tubuli membranacei are the semicircular tubes which pass along the osseous semicircular canals, and to which the latter are subservient, merely as supporting them. They are connected by means of the common alveus in the vestibule, and form a distinct division of the organ.

It was believed by anatomists formerly, that the osseous canals had the pulp of the nerve expanded on their periosteum. But we find, on the contrary, that the membranous tubuli do not touch the bones, but are connected with them by transparent cellular membrane-like mucus. Each of the semicircular membranous tubes has one extremity swelled out into an ampulla of an oval form, answering to the dilated extremity of those osseous tubes which we have already described. These ampullæ have the same structure and use with those formerly mentioned in describing the ear in fishes. When the central belly of these tubes is punctured, both the ampullæ and the membranous canals fall flaccid.

Besides those vessels which we have described running along the periosteum of the cavities of the labyrinth, vessels also play upon the sacculi and membranous tubes. The ampullæ of the tubes are, in a particular manner, supplied with blood-vessels.*

In the cochlea there is also a pulpy membrane, independent of the periosteum; but of this I can say nothing from my own dissection.

* "Cæterum universum hoc canaliculorum membraneorum alveique communis machinamentum, sanguiferis vasis instruitur, quorum crassiora, circum alveum communem, serpentino incessu ludunt; crebra et conferta alia *ampullæ* imprimis recipiunt ob quam causam rubellæ plerumque sunt et cruore veluti suffusæ." *Scarpa*, p. 57.

OF THE NERVE.

As the seventh pair of nerves arise in several fasciculi, they form what would be a flat nerve, were it not twisted into a cylindrical form adapted to the foramen auditorium internum. While these fasciculi are wrapped in one common coat, they are matted together. In the canal, the nerve is divided nearly into two equal parts *; to the cochlea and to the vestibulum and semicircular canals. Those fasciculi, which are destined for the vestibule, are the most conspicuous; and on the portion destined for the ampullæ of the superior and external canal there is formed a kind of knot or ganglion.

Before the auditory nerves pass through the minute foramina in the bottom of the meatus auditorius, they lay aside their coats, and become more tender and of a purer white colour; and by being still further subdivided by the minute branching and divisions of the foramina, they cannot be followed, but finally expand in a white pulpy-like substance on the sacs and ampullæ. We must, however, recollect that there was a difference to be observed in the apparent texture of these expanded nerves in the lower animals: we may observe here, also, that part of the nerve which is expanded on the common belly or sacculus tubulorum, is spread like a fan upon the outer surface of the sac, and has a beautiful fibrous texture; but upon the inside of the sac upon which it is finally distributed it loses the fibrous appearance. We must suppose its final distribution to be in filaments so extremely minute that we may call it a pulp; though by the term it must not be understood that an unorganised matter is meant.

That part of the nerve which stretches to the ampullæ immediately divides into an opaque white mucous-like expansion. Beyond these ampullæ there has been no expansion of the nerve discovered in the membranous tubes.

The sacculus vestibuli † is supplied by a portion of

* Of the portio dura we have already spoken.

† *i. e.* In opposition to the sacculus tubulorum.

the nerve which perforates the macula foraminolosa, in the centre of the osseous excavation, or that which receives into it part of the sac. This part of the nerve is expanded in a soft mucous-like white matter in the bottom and sides of the sac.

A division of the nerve, as we have already explained, passes from the meatus auditorius internus through the cribriform base of the modiolus into the cochlea. Owing to the circular or spiral form of the foramina when the nerve is drawn out from the meatus, its extremity appears as if it had taken the impression of these foramina from the extremities of the torn nerves preserving the same circular form. These nerves, passing along the modiolus and scalæ cochleæ, are in their course subdivided to great minuteness. Part of them perforate the sides of the modiolus, whilst others pass along betwixt the two plates of the lamina spiralis, and out by the minute holes in the plates and from betwixt their edges. Lastly, a central filament passes up through the centre of the modiolus, and rises through a cribriform part into the infundibulum to supply the infundibulum and cupola.

Where the nerves pass along the lamina spiralis, their delicate fibres are matted together into a net-work. According to the observations of Dr. Monro, they are quite transparent on their extremities.

OF HEARING.

When aërial undulations were, by the experiments on the air-pump, first proved to be the cause of sounds, philosophers looked no further to the structure of the ear than to discover an apparatus adapted for the reception of such vibrations. When they observed the structure of the membrane of the tympanum, and its admirable capacity for receiving these motions of the atmosphere, they were satisfied, without considering the immediate objects of sensation. In the same way, an ignorant person, at this day, would rest satisfied with the fact that sound was received upon the drum of the ear. But

after so minutely explaining the anatomy of the ear, it becomes us to take a general survey of a structure the most beautiful which the mind can contemplate. We cannot say that it surpasses in beauty the structure of other parts of the body: but the parts are adapted to each other, in a manner so simple, efficient, and perfect, that we can better understand and appreciate the harmony of their structure than that of organs which perform their functions by qualities and actions almost entirely unintelligible to us.

We see that the external ear collects the vibrations of sound as it moves through the atmosphere in circular undulations proceeding from the sonorous body: we may observe, that where the necessities of animals require them to be better provided with this external part of the organ than man, the superiority is in the increased sensibility to sounds, and in judging of their direction. Notwithstanding it is obvious that the horse and ass, for example, use their ears to judge of the direction of sound, experiments of cutting off these appendages, we are told, have not hurt the power of the organ; and man, from the perfection of the internal organ, excels all animals in the capacity of the ear for articulate and musical sounds.

From the external ear we observe, that the trumpet-like tube conveys the sound inward to the membrane of the tympanum. Behind the membrane of the tympanum, there is a cavity which, in order to allow of the free vibration of the membrane, contains air. When this air is pent up, by the swelling or adhesion of the Eustachian tube, the elasticity of the air is diminished, and the membrane prevented from vibrating.*

In the tympanum, we have seen that the operation of the chain of bones is to increase the vibration received upon the membrane of the tympanum, and to transmit it to the membrane of the foramen ovale. In the cavity of the tympanum we observed two foramina, the foramen ovale and the foramen rotundum, both of which

* See *Recherches, &c. relatives à l'organe de l'ouïe et à la propagation des sons*, par M. Perolle, Sociét. R. de Médecine, tom. iii.

lead into the labyrinth; but one of them (the foramen ovale) into the vestibule, the other (the foramen rotundum) into a scala of the cochlea: now it becomes a question, whether the oscillations of sound pass by one or by both of these foramina?

It is contended, that the sound passes in both ways, that is, along the solid bones, and through the air of the tympanum. Did it pass through the air, why is there all this expense of apparatus? — why a membrane of the tympanum; for unless the impressions of sound were to be conveyed as powerfully through the air as by the bones, why are they there at all? If the air were the medium, then the chamber containing it should be direct and regular. Again, it is with the same inconsistency maintained that the tympanum is more capacious in the elephant, and in nocturnal birds, so as to increase the acuteness of hearing. The obvious objection to this is, that the walls of the cavity are irregular in a singular degree, with minute cells, spines, and processes, presenting no where a regular concave for reverberation. If a person should show me an irregular piece of rock crystal, opaque white, from the variety of its reflecting surfaces, and say it was a lens, I would as soon believe it was a magnifying glass, as that the cells of the cavity of the tympanum were for reverberating and directing the sounds.

An absolute confusion of ideas has led to the opinion, that the foramen rotundum receives the undulation of the air. It is not enough to state to those *physiologists*, that the foramen ovale is directly opposite the membrane of the tympanum, and the foramen rotundum turned away from it. No, they say, that is the very reason, because it does not receive the impulse directly, but by reverberation, and obliquely. If there were any hope of arguing against these opinions, we might state the matter thus; — if the sounds arrived from different sources, and came in various directions, they might (if the surfaces were regularly adapted) be reverberated to some common centre, and thereby strengthened (of which we have an example in the outward ear); but the sound comes only by the motion of the membrane of the

tympanum, through the tube of the ear: it is already concentrated; and if it were now to be directed against the walls of these passages, it might be dissipated, but how is it to be concentrated again?—and if concentrated, in what degree can it be stronger than when it entered the tympanum?

In the labyrinth there is no air, but only an aqueous fluid: now this, we have seen, conveys a stronger impulse than the atmosphere; stronger in proportion to its greater specific gravity and want of elasticity; for an elastic fluid like air may be compressed by concussion, but an inelastic fluid must transmit fairly every degree of motion it receives. But if the fluid of the labyrinth be surrounded on all sides; if, as is really the case, there can be no free space in the labyrinth, it can partake of no motion, and is ill suited to receive the oscillations of sound. Against this perfect inertia of the fluids of the labyrinth I conceive the FORAMEN ROTUNDUM to be a provision. It has a membrane spread over it, similar to that which closes the foramen ovale. As the foramen ovale receives the vibrations from the bones of the tympanum, they circulate through the intricate windings of the labyrinth, and are again transmitted to the air in the tympanum by the foramen rotundum. Without such an opening there could be no circulation of the vibration in the labyrinth; no motion of the fluids communicated through the contiguous sacculi, nor through the scalæ of the cochlea; because there would be an absolute and uniform resistance to the motion of the fluids. But as it is, the provision is beautiful. The membrane of the foramen rotundum alone gives way of all the surfaces within the labyrinth, and this leads the course of the undulations of the fluid in the labyrinth in a certain unchangeable direction.

To me it appears, that to give a double direction to the motion of the fluids, or to the vibration in the labyrinth, far from increasing the effect, would tend to annihilate the vibrations of both foramina by antagonising them. The common idea is, that there is a motion communicated through the membrane of the foramen

rotundum along the scala tympani, and another through the foramen ovale into the vestibule, and through the vestibule into the scala vestibuli; and that the concussion of these meet in the infundibulum of the cochlea. But as there is no space for motion in the fluids, in either the one or other of these tracts, the vibration must have been received in the infundibulum at the same time that the motion was communicated to the membranes of the foramen ovale and rotundum; *for* if a tube full of water, a mile in length, looses one drop from the extremity, there must be an instantaneous motion through the whole to supply its place. The evident consequence of this double impulse would be (if they were of the same strength) to suppress all motion in the fluids of the labyrinth.

But we have shown that the strength of the vibration communicated to the foramen ovale and foramen rotundum are not the same: for the mechanism of the bones in the tympanum is such as to accumulate a greater force or extent of motion on the membrana ovalis than is received upon the membrana tympani; therefore the lesser vibration, which is communicated through the medium of the air in the tympanum, cannot be supposed capable of opposing the stronger vibration which is conveyed from the foramen ovale through the labyrinth. Besides, the air in the tympanum has a free egress, and cannot therefore strike the membrane on the foramen rotundum forcibly.

For these several reasons, I conceive that the following account of the manner in which the sound is conveyed is erroneous:—"Et quo ad zonam cochleæ spiralem quoniam altera cochleæ scala in vestibulo patet, altera a FENESTRA ROTUNDA initium sumit, atque earum utraque aqua labyrinthi repleta est, et scalæ in apice cochleæ simul communicant, zona spiralis inter duas veluti undas sonoras media, a tremoribus per vasim stapedis, simulque ab iis per membranam *fenestræ rotundæ* advectis utraque in facie percellitur et una cum pencillis acoustici nervi per eam distributis contremiscit: quibus porro omnibus, in ampullis videlicet canaliculorum semicircularium

alveo eorum communi, sacculo vestibuli spherico et lamina cochleæ spirali acoustici nervi affectionibus auditum contineri nemo non intelligit." *

As to the immediate seat of the sense of hearing, there cannot, after what has been explained regarding the distribution of the nerves, remain any controversy; though before the structure of the ear was so well understood, some imagined that the vestibule, others that the middle part of the semicircular canals, was the seat of hearing; others, again, that the lamina spiralis was better adapted for receiving the vibrations of sound. It is evident that the soft expansion of the nerve, in all the three divisions of the labyrinth, is destined to receive the undulation of the contained fluids, and that this motion of the fluids gives to the nerve, or to the nerve and brain conjointly, the sensation of hearing.

Since we have, in some measure, traced the structure of the ear from the animals of a simple structure to those of a more complicated organisation, and have observed some parts of the ear common to all animals, some peculiar to certain orders; and since all have the sense of hearing, more or less acute, it becomes natural to enquire what are the parts of the organ the most essential to the mere perception of sound, and what parts conduce to a more perfect state of the sense.

All the external apparatus of the ear is not necessary to give the animal the simple perception of sound. There are many classes of animals altogether without them, and even in man we see that they are not absolutely necessary; since, when deprived of them by disease, he still enjoys the sense. He is deprived of no essential variety of the sensation: he is capable of perceiving the distinctions of articulate sound; and still possesses his musical ear. The external apparatus of the ear, the membrane of the tympanum, and the little bones, receive, concentrate, and increase the tremors of the external air, and render the lesser motions or more acute impressions audible. They are not essential to hearing. These are the parts calculated only to receive

* Scarpa, p. 61.

the minute undulations of the air, and to perfect our sense of acute sounds.

It would appear, that the simple sac of the vestibule is sufficient to receive the impression in some animals, and that in many the vestibule and semicircular canals form all the organ of hearing. It is evident, therefore, that these are the most essential parts.

We find, however, that the cochlea exists, though it be imperfect, in birds; that it is fully formed only in man, and in quadrupeds: from which we may conclude, that it is subservient to the more exquisite sensations. We are not, perhaps, warranted in concluding that any one part of the organ of hearing bestows the pleasures of melody and harmony, since the musical ear, though so termed, is rather a faculty depending on the mind. Yet, when we see that the sacculi of the vestibule is common to all creatures; and the semicircular canals common to fishes, birds, and beasts; and when, in the lamina spiralis of the cochlea, we see a more perfect preparation for variety of impression; and which by comparative anatomy is marked as the perfection of the organ of hearing, we are naturally drawn to observe this part more narrowly.

Even after studying, with all diligence, the anatomical structure of the ear, we cannot but be astonished with the varieties to be found in the sensation; for example:—" The ear is capable of perceiving four or five hundred variations of tone in sound, and probably as many different degrees of strength; by combining these, we have above twenty thousand simple sounds that differ either in tone or strength, supposing every tone to be perfect. But it is to be observed, that to make a perfect tone, a great many undulations of elastic air are required, which must all be of equal duration and extent, and follow one another with perfect regularity; and each undulation must be made of the advance and recoil of innumerable particles of elastic air, whose motions are all uniform in direction, force, and time. Hence we may easily conceive a prodigious variety in the same tone, arising from irregularities of it occasioned by constitution, figure, situation, or manner of striking the sonorous body; from the constitution of

the elastic medium, or its being disturbed by other motions; and from the constitution of the ear itself upon which the impression is made. A flute, a violin, a hautboy, a French horn, may all sound the same tone, and be easily distinguishable. Nay, if twenty human voices sound the same note, and with equal strength, there will still be some difference. The same voice, while it retains its proper distinctions, may yet be varied many ways: by sickness or health, youth or age, leanness or fatness, good or bad humour. The same words, spoken by foreigners and natives, nay, by different provinces of the same nation, may be distinguished." *

There are several interesting subjects which have not met with sufficient attention. On what does this variety in the sensation depend? Does the vibration strike on different parts, and re-echo along different passages of the labyrinth, so as to move particular divisions of the auditory nerve? Or does the whole fluid of the labyrinth move in every sound, and is every filament of nerve struck? I must suppose that the first opinion is true. It appears necessary, to account for that extraordinary compass and variety in the sensations of this organ. And if the varieties in the impression had resulted from a pulse agitating indiscriminately the whole nerve, it would seem that the object would have been better accomplished by the uniform expansion of the medulla of the nerve over all the surfaces and cavities, as in the eye. But as, on the contrary, the medullary matter lies in patches, it is probable that those are the centres where undulations of sound meet, reflected from the surrounding vaults.

In an elliptical chamber, a person standing in one of the foci is heard in a whisper by a person standing in the other focus: for by the regular elliptical form, the waves or pulses are reflected to the foci. The vestibule has regular concavities, which we can imagine to produce such a concentration of sound. The cavity of the tym-

* Reid's Enquiry, p. 98.

panum, on the contrary, having no such regularity of form (as I have argued above), can produce no such concentration of the pulses of sound.

Another difficulty presents in accounting for the direction of sound. Authors have left us quite in the dark on this subject. That two ears, by receiving the impressions unequally as we turn the head, affords a means of judging of the directions of sounds, is obvious; but we possess the same power through the operation of one ear. Some have been so hardy as to explain this on the supposition that the impressions are received on the head, and that we judge in this manner of the direction of them; which were, I think, to make the ear a superfluous ornament. Are the sounds reflected from the different surfaces of the outer ear, so as differently to affect the membrane of the tympanum and the adjoining muscles? it is not easy to prove this. Does ventriloquism throw any light on this subject? If we know how we are deceived in the direction of sounds, we may learn by what means we judge of them. This would make the modifications of the intensity of impression the means by which we judge of the direction of sound. It may countenance such an explanation if we consider the nicety with which we judge of the distance of a sonorous body; we judge, at least, as accurately of distance by the ear as by the eye.

I must again repeat that the cochlea is the more important part of the organ, or rather the refined and higher part of the apparatus; for the vestibule is universal, and the semicircular canals common to fishes, birds, and quadrupeds. We think that we find in the lamina spiralis the only part adapted to the curious and admirable powers of the human ear, for the enjoyment of melody and harmony. It is in vain to say, that these capacities are in the mind and not in the outward organ. It is true, the capacity for enjoyment, or genius for music, is in the mind. All we contend for is, that those curious varieties of sound which constitute the source of this enjoyment, are communicated through the ear, and that the ear has *mechanical* provisions for every change of sensation.

There is no part of the proper organ which appears susceptible of the variety of musical notes but the scala of the cochlea. Its breadth is in regular gradation of parts from the base towards the point or apex; and whether the fibres were to be taken as the cords of a harp, or the tubes like the ora of a wind instrument, every gradation of sound may be supposed to have here its corresponding organ to vibrate, and by its vibration to move a distinct part of the auditory nerve.

Let us, then, turn to the consideration of the effects of these musical tones upon the mind.

There is nothing more curious than the relations established betwixt the senses and the ruder bodily operations. We have seen how the motions of the body and limbs added to the perfection of the eye, an organ which we should suppose neither required nor admitted addition of powers from so unexpected a source. The motions of the limbs are in constant relation to the enjoyment received through the ear, from the tatooing with the fingers on the table to the richest combination of sounds from a whole orchestra; for, in all this compass of enjoyment, rhythm is a necessary part.

Rhythm is a regular and agreeable return of an expected note with which the body readily accords. We cannot walk, nor jump, nor dance, nor strike with a hammer, without feeling a desire that the stroke should be in a certain regulated succession. This is rhythm, and is a necessary part of music. Melody is something more; it is a succession of notes which bear a relation in the time of their vibrations; the sound still dwelling on the memory is succeeded by sounds which, from the proportions of their vibrations, are agreeable and melodious. Harmony is the concurrence of sounds which correspond in certain of their vibrations. Music has another power over us by a resemblance to the expression of human suffering and passion, by which a melody is continually suggesting circumstances of interest, while by association it unlocks the memory, and keeps the mind revolving in agreeable reverie.

OF THE DISEASES OF THE INTERNAL EAR.

Of all the causes of deafness, that which proceeds from an organic disease of the brain is, of course, the most dangerous. In apoplectic affections, with faltering of speech and blindness, deafness is also produced by the general affection of the brain. But worst of all is the case where a tumour of the brain, or betwixt the cerebrum and cerebellum, compresses the origin of the nerves.* I have, however, observed, that a tumour in the *vicinity* of the origin of the auditory nerve, though it ran its course so as to prove fatal, had rather a contrary effect on the organ of hearing; and while the pupil of the eye remained stationary, and the man saw indistinctly, he had a morbid acuteness of hearing. This had probably been produced by the surrounding inflammation having extended to the origins of the auditory nerves. The auditory nerve often becomes morbidly sensible, and the patient suffers by the acuteness of perception, or is distressed with the tinnitus aurium, which is, in this case, analogous to the flashes of light which sometimes affect the eye in total darkness, and which those experience who are totally blind, or have cataract. So morbidly acute does the sensation sometimes become, that the slightest motion of the head will excite a sensation like the ringing of a great bell close to the ear.† With delirium, vertigo, epilepsy, hysteria, the increased sensibility of the organ becomes a source of painful sensation.

* Vidit Clariss. Dom. Drelincurtius Tumorem steatomatis consistentia pugnique magnitudine, cerebrum et cerebellum inter, eo præcisè loco ubi conarium utrique substeritur choroidis plexus alæ, spatio semestri a sensibili læsione, cæcitatem primo, surditatem subinde, omnium denique sensuum et functionum animalium abolitionem et necem ipsam intulisse." Bonnet. vol. i. p. 123. ob. 53. In Sandifort, Obs. Anatom. Path. tom. i. p. 116., there is an instance in which the auditory nerve had a cartilaginous tumour adhering to it.

† F. Hoffmann. Consult. et Respons. Cas. xxxix. We must not, however, take his reasoning after what we have seen of the structure of the ear, that the viscid pituita, separated in the concha, cochlea, and labyrinth, resolved into halitus endeavouring to escape, produces the susurrus et tinnitus aurium.

The ear is sometimes affected by sympathy of parts: for example, from foulness of the stomach and bowels, as it is termed; and the same reason may be assigned for the complaint of hypochondriacs, that they are molested with strange sounds. In the case of intestinal worms, we find the patient complaining of murmuring and ringing in the ears.* Of the organic diseases of the labyrinth there is little on record. It would appear, that the fluids become often so altered in their consistence as to prove an absolute destruction to the organ. Mr. Cline found in a person deaf from birth, that the whole labyrinth was filled with a substance like cheese. A disease of the auditory nerve, like that of the retina in the gutta serena, is no unfrequent complaint.†

Deafness, in acute fever, is a good sign; because, say authors, it argues a metastasis of the morbific matter. We should rather say, because it argues a diminution of the morbid sensibility of the brain.‡ But the surcharge of the vessels of the brain or of the auditory nerve will also produce deafness and unusual sensations in the ear; as in suppression of the menses and hæmorrhoids, in surfeit, &c., in which cases it is often preceded by vertigo and head-ach.

There occurs a very curious instance of analogy betwixt the ears and eyes, in the following cases: — "A certain eminent musician, when he blew the German flute, perceived at the same time the proper sound of it, and another sound of the same rhythm or measure, but of a different tone. His hearing seemed thus to be doubled. It was not an echo; for he heard both sounds at one and the same moment: neither were the sounds

* Hoffmann. Med. Consult. Boerhaave. The sympathy is sometimes exerted in a contrary direction. *Sauv.*

† Dysecœa (atonica) sine organorum sonos transmittentium vitio evidente. *Cullen.* Cophosis *Sauv.* *Cophosis* a *Paracusi* distinguitur ut *amaurosis* ab *amblyopia* respectiva. *Sauv.*

‡ But the difficulty of knowing when the deafness is the result of disease, or malconformation in the parts transmitting the sound to the nerve, and when in the brain and nerve, has led to more uncertainty and confusion with regard to the species and varieties of the disorders of the ear than in the eye, where the transparency of the humours assist in the definition.

accordant and harmonious, for that would have been sweet and pleasant to his ear. Having for several days persisted in his attempts, and always been shocked with this grating sound, he at last threw his flute aside. The day before he first became sensible of this strange affection, he had imprudently walked in a very cold and damp evening, and was seized with a catarrh in the right side. Whence, probably, it arose that the natural tone of that ear was altered: the sound appeared more grave, and dissonant from that received by the left ear. Having recovered from the catarrh, the distinct hearing of his ear was restored."

Sauvages, who relates this case, subjoins another: — "Very lately," says he, "a foreigner came for advice in a similar situation. He complained, that when any person spoke to him, he heard the proper sound of the voice, and at the same time another sound accompanying it an octave higher, and almost intolerable to him. As it must have happened, that, if the accompanying sound had preserved the true octave above the voice, and been synchronous with it, the ear would have received them as one sound, and been pleased with their concord, it is probable that the accompanying sound was not in unison with the true." Sauvages, vol. iii. p. 352.

OF THE NOSE AND THE ORGAN OF SMELLING.

OF THE SENSE OF SMELLING.

Smelling seems to be the least perfect of the senses. It conveys to us the simplest idea, and is the least subservient to the other senses. The sensation it presents

to us we can less easily recall to memory; and the associations connected with it are less precise and definite than those of the senses of hearing and seeing; finally, we should lose this sense with less regret than any other.

Animal and vegetable bodies, during their life, growth, putrefaction, and fermentation, and, most probably, all bodies whatever, are perpetually giving out effluvia of great subtilty. Those volatile particles repelling each other, or diffused in the atmosphere, are inhaled by the nose, and convey to the pituitary membrane of the nose the sensation of smell. Even in the outward form and structure of the nose, there is a relation to the exercise of this sense; the lateral cartilages of the nose, or those which form the nostrils, possess a degree of elasticity adapted to preserve the passage open and free. They have muscles adapted to move them, to expand them when greater freedom of respiration is required, and to contract them in order to diminish the stream of air, and to give it more force to penetrate to the upper cavities of the nose. The cartilage which joins to the septum of the nose is also flexible and moveable by muscles, which curve the nose or draw down the point; thus, in smelling, the air, which in ordinary respiration passes freely backwards, is directed upwards to the æthmoid bone; these cartilages perform another office in giving that flexibility to this prominent feature, which enables it to elude injuries and at the same time protect the bones of the nose: but their chief use is in connection with the sense; for it may be observed, that when we draw the air in, in smelling, the nostrils are compressed, which gives more force to the air received, and at the same time the direction of the stream of air is changed. When we breathe with the nostrils stationary or expanded, the air passes directly backwards, but when it is drawn in, in smelling (the nose being drawn down), a direction upwards is given to the stream of air, so that it is made to circulate about the cells of the æthmoid bone, where the olfactory nerve is expanded.

Immediately within the nostrils, there are two cavities separated by the bony partition, which has been already

described in treating of the bones. These cavities enlarge as they proceed inward, and open backward into the throat, and, consequently, communicate with the mouth. They extend upward and sideways into the cells of the bones of the face; and the pituitary membrane is extended over the surfaces of these winding passages, and over the irregular surfaces of the nose, formed by the projecting cartilages of the æthmoid and lower spongy bones; which, also, have already been sufficiently described.

The cavities of the nose lead into many cells in the bones of the face, which, though not the immediate seat of the sense, are subservient to the organ by permitting a circulation of the air, and thus carrying the effluvia into contact with the nerve. No doubt these cavities are also useful in giving vibration and tone to the voice. The cavities of the nose are continued upwards into the frontal sinuses, and into the cells of the æthmoid bone; backward and upward into the sphenoid sinus; and upon the sides into the antra Highmoriana or sinuses of the upper maxillary bones.

The membrane covering the surface of these bones is called the MEMBRANA SCHNEIDERIANA, the mucous or pituitary membrane. It is of a glandular structure, or is lubricated by the mucus discharged by the follicles on its surface. This secretion on the surface of the membrane, is to defend its delicate and sensible structure from the effects of the air, while it preserves the sensibility of the surface and the delicate expanded nerve. It seems of a nature to allow the effluvia to penetrate it.

A very particular provision has been made against the too powerful effect of smells while the membrane is inflamed, and, consequently, in a state of great sensibility. When the membrane is inflamed, the secretion is altered, and the effluvia does not penetrate, nor does it affect the nerve in its state of extreme sensibility.

We have already described the course of the first pair of nerves or the olfactory nerves, and also those branches of the fifth pair of nerves which are distributed to the membrane of the nose. These, it were superfluous to recapitulate here. The olfactory nerve alone is the

organ of smelling, and the branches of the fifth pair bestow merely common sensibility to the membrane.

I have traced branches of the fifth nerve into all the cavities of the face, and we feel that they possess sensibility. In applying volatile salts to the nostrils, we can distinguish a painful sensation to rise into the frontal sinuses different from the sense of smelling. When the root of the nose has been broken in and the cavity opened, experiments have been made by sending effluvia upwards into the frontal bone, and no sense of odours was experienced: but when they were admitted downwards to the æthmoid bone, the first nerve was affected, and the sense exercised. This sensible and nervous membrane, being also glandular and secreting, is very vascular; and this vascularity, this glandular structure, and its exposed state, make it liable to frequent disease: and, when diseased, when tumours and polypi form in it, we must never forget the extreme thinness and delicacy of the surrounding bones, which, when they are either pressed upon by tumours, or have their membranes eroded, are soon totally destroyed. It is with manifest design, that this organ, which so particularly admonishes us of the effluvia diffused in the air we breathe, should have been placed in the entrance to the canal of the lungs. It is, in some measure, a guard to the lungs, as the sensibility of the tongue guards the alimentary canal. That the humidity of the membrane either preserves the sensibility of the nose, or is a solvent, in which the effluvia dissolving affect the nerves, is evident; for the sense is lost when the membrane becomes dried. The sensibility is also affected in various ways by too abundant a mucous discharge, or by an alteration of its natural properties; by the infarction and thickening of the membrane, as in ozæna; by obstructions preventing the current of air through the nose, as in polypi, &c.

The acuteness of sensation in this organ is most probably lost by our habits, by our relying on other senses, by the incessant application of artificial odours to the organ. Those who have believed in the variety of the human species, and the approximation of some tribes to

the brute, dwell much on the acuteness of sensation enjoyed by negroes, and their wider nostrils.*

There is nothing more curious than the spontaneous exercise of the organs of the senses. Thus we have bad taste in the mouth, ringing in the ears, sparks of fire before the eyes, when there has been no outward impression made upon the organ; and so have we rarer examples of disease putting even the organ of smelling into exercise. A young gentleman, a sudent, was attacked with a complaint in his Schneiderian membrane, which changed the nature of its secretions. During this disease he was assailed with the most disagreeable odours, a circumstance not so uncommon; but the unpleasant exercise of the sense was sometimes relieved by his experiencing the most delightful and fragrant effluvia, which were not in existence, but proceeded either from the spontaneous operation of the organ of sense, or from morbid irritation upon it.

OF THE MOUTH, SALIVARY GLANDS, THE ORGAN OF TASTE, &c.

OF THE MOUTH AND TONGUE.

The mouth is that cavity anterior to the velum or fleshy palate; the posterior cavity is the fauces; the mouth is for mastication and speech, the posterior cavity is a common passage, admitting the food to be conveyed into the œsophagus, and the air to be drawn in from the nostrils into the trachea.

* *Pallas* says, the Calmuck, by applying his nose to the hole of a fox, or any other beast, can tell whether he be at home or not.—See *White of Manchester*.

The lips and cheeks are formed of the skin and reflected mucous membrane, with muscular fibres intervening to give them pliancy and motion, and with minute glands to discharge the moisture on their inner surfaces.

The glands of the lips are called *glandulæ labiales*, and are very numerous; those of the cheeks are called the *glandulæ buccales*.

OF THE TONGUE.

The BODY of the tongue consists of muscular fibres, with intermingled fat and cellular membrane, nerves, and blood vessels.

The BASE of the tongue is that part which is backward, and is connected with the os hyoides: the apex is anterior.

The surface applied to the roof of the mouth is called DORSUM. On this surface there is to be observed a middle line, dividing the tongue into two lateral portions; a division which is very accurately preserved in the distribution of the blood vessels and nerves of either side. On the dorsum, towards the base, the surface is rough with the papillæ maximæ and foramen cæcum Morgagni.* These papillæ are like small glands seated in little superficial fossulæ, so that their broad mushroom-like heads alone are seen; but they are connected with the bottom of the fossulæ by short stems or necks. This is considered as a glandular apparatus. The foramen cæcum is, in truth, only an enlarged apparatus of the same kind, for, in the bottom of this foramen, many glandular papillæ stand up; and in its bottom small foramina have been observed, which are generally conceived to be the mouths of small salivary ducts. Morgagni himself, however, seems only to have seen a small duct opening into this foramen in one subject of many which he examined. In *Haller's opuscula* there is a dissertation on the *Ductus Coschwizianus*, which was supposed to carry the saliva from the sublingual

* Adversar. Anat. VI. Animad. XCIII.

gland to the middle of the tongue, and also into the throat, but it turns out to be a vein only. It is curious to observe the necessity the author discovered for these ducts, when he thought he had found them.* The secreting mucous surface begins here, towards the root of the tongue, to resemble the glandular structure of the œsophagus, which, by bedewing the surface of the morsel, fits it for an easy passage through the gullet. This roughness of the root of the tongue is, at the same time, a provision for the detention of the sapid particles, and consequently prolonging of the sensations of taste.

The PAPILLÆ of the human tongue are divided into four classes. 1. Those larger papillæ upon the root of the tongue are the truncatæ; and they are often studded on the dorsum of the tongue in a triangular form. 2. The fungiformes are obtuse papillæ found more forward on the tongue; they are little hemispherical tumid papillæ, with an obtuse surface. 3. The latter are interspersed among the third division, the most numerous and universally prevalent papillæ, viz. villosi or conoideæ; they are, as Soemmerring says, of various forms, angular, conical, obtuse. 4. The vaginatæ are the more important papillæ, however; they are endowed with peculiar sensibility to sapid bodies; are to be distinguished by their superior redness and brilliancy, and are placed upon the point and edges of the tongue.

The tongue is invested with the cuticle and rete mucosum, like the skin in other parts. The lower surface of the tongue is similar to the general lining membrane of the mouth, being a soft villous and secreting surface. It is reflected off upon the bottom of the mouth, where it forms the FRENULUM LINGUÆ. This ligament seems evidently intended to limit the motion of the point of the tongue backwards. A very false opinion has prevailed, that the shortness of this ligament, or its being continued too far forward toward the point of the tongue, prevents the child from suck-

* Vater, who injected these ducts, found them terminating in a gland near the os hyoides; and the opinion was, that they had even a connection with the thyroid gland. Heister was of the same opinion.

ing. The tongue, as I conceive, would sufficiently perform the necessary action on the mother's nipple, although its lower surface were universally adhering to the bottom of the mouth. But, observe the bad consequences which may arise from yielding to the obstinate importunity of the nurse, and cutting this frenulum. The ranine vein or artery which runs near it may be cut, and the child will continue sucking and swallowing its own blood; and children have actually died, and the stomach has been found distended with blood! But there is another more dreadful accident from this cutting of the frenum linguæ. A child, says M. Petit, whose frenum had been cut almost immediately after its birth, was suffocated and died five hours afterwards. They believed that the operation was the cause of the child's death; they sent for me to open the body. I put my finger into its mouth, and I did not find the point of the tongue, but only a mass of flesh which stopped up the passage from the mouth into the throat. I cut up the cheeks to the masseter muscles, to see what had become of the tongue. I found it turned like a valve upon the fauces, and the point actually swallowed into the pharynx. "Some time after," continues M. Petit, "I was called to the child of Mr. Varin, Sellier du Roi, whose frenum they had cut two hours after its birth, and who, a little after, had fallen into the same situation with the child I have now mentioned, and was nearly suffocated. My first care was to introduce my finger: the tongue was not, as yet, entirely reversed into the throat. I brought it back into the mouth; in doing which, it made a noise like a piston when drawn out of its syringe." M. Petit waited to find the effect of its sucking, and after hearing the action of deglutition for some minutes, the child fell again into the same state of suffocation. Several times he reduced the tongue, and at last contrived a bandage to preserve it in its place; but, by the carelessness of the nurse, the accident recurred, and the child was suffocated during the night. There can be no better illustration of the use of the frenum linguæ.

OF THE SALIVARY GLANDS.

The sources of the saliva are very numerous: the parotid or superior maxillary glands, and sociæ parotidis; the inferior maxillary or submaxillary glands; the sublingual glands; and (according to the opinion of many) the glandular follicles of the root of the tongue, the palate, and even the buccales and the labiales, or glands of the cheeks and lips, are also to be enumerated, as sources of saliva. But the chief source of the saliva is in the proper salivary glands.

The PAROTID GLAND, as its name implies, is that which lies near to the ear. It is the largest of the salivary glands; and it is of much importance for the surgeon to observe its extent and connections. A great part of it lies before the ear, and betwixt the ear and jaw. It extends over the masseter muscle, and upwards to the zygoma. But there is also a great part of it which lies below the tip of the ear, and betwixt the angle of the jaw and the mastoid process. Its surface is unequal, and composed of little masses or lobules of gland, united by a cellular membrane. The duct of this gland was discovered by Needham, and afterwards by Steno: it is very often called Steno's duct. When it is injected with quicksilver, the branches are seen distributed in a most beautiful and minute manner amongst the lobuli of the gland, like the branching of veins. These branches have a direction upward from the gland, and unite into a trunk, which passes from the upper part of the gland across the cheek over the origin of the masseter muscle: it then pierces the buccinator muscle, and opens upon the inner surface of the cheek, opposite to the second dens molaris. This duct has strong white coats; but, although the mouth of the duct is very small, the duct itself is dilatable. *

The SOCIA PAROTIDIS is a small gland, not constantly to be found, seated on the upper side of the duct of

* A friend of mine having introduced a silver tube into the salivary duct to cure a fistula, it slipped in and was lost; that is, it was necessary in the end to cut it out by an operation near the angle of the jaw.

the parotid gland, and just under the margin of the cheek bone. It opens by a lesser duct into the greater duct of Steno. Sometimes, however, instead of one considerable gland, there are several small ones, seated in the course of the great duct, and opening into it by several minute ducts.

The SUBMAXILLARY GLAND is of a regular oval figure, and is seated under the angle of the jaw; it lies under the platysma myoides on the tendon of the digastric muscle; it is defended by the angle of the lower jaw, where it is generally connected with or involves the root of the facial artery. It is regularly lobulated; and its duct passes forward between the genio-glossus and mylo-hyoideus, and under the sublingual gland. The openings of the submaxillary ducts, or ducts of Wharton, are very easily distinguished. They open under the tongue very near each other, on each side of the frenum linguæ; so that they appear as if tied down by the frenum. When these are excited to discharge their fluids, they become a little erected; their open mouths are seen distinctly, and even the tortuous course of their canal in the bottom of the mouth may be seen.

The SUBLINGUAL GLAND is of a flat and elongated form; it lies close under the tongue between the genio-hyo-glossus and mylo-hyoideus muscles. It is the smallest of the three great salivary glands. The two sublingual glands, stretching close under the tongue, are separated from the cavity of the mouth only by the membrane of the mouth. The duct of the sublingual gland opens into the duct of Wharton at the same time that it opens by small lateral ducts, with loose pendulous mouths, upon the lower surface of the tongue.

The *glandulæ molares* are seated betwixt the masseter and buccinator muscles: they properly belong to the class *buccales*. These are small glands, in some measure incorporated with the cheek. The *glandulæ labiales* are more distinct, and can be insulated by dissection: they are round and flat, and sunk in the substance of the lips. All these glands secrete into the mouth.

From the general surface of the lips, tongue, cheek,

and palate, there is a fluid exhaled. This exhaling surface and all those glands are excited to action by the same stimulus, the excitement of the morsel in the mouth. The saliva moistens the surface of the mouth, assists in manducation, prepares the food to be swallowed and acted upon by the stomach, and accelerates digestion. As the mouth is an exhaling surface, so is it an imbibing and absorbing surface. Calomel may be rubbed upon the mouth so as to salivate.

VELUM PALATINUM; UVULA; ARCHES OF THE PALATE; AND AMYGDALÆ.

The VELUM PENDULUM PALATI is the vascular and fleshy membrane, which, hanging from the bones of the palate, divides the mouth from the fauces. It is not a simple membrane, but has betwixt its laminæ many glands, which open upon its surface by little follicles, and it is thickened and strengthened by muscular fibres, so that it is more like a fleshy partition, stretching backward and eking out the palate, than a hanging membrane.

The edge of the velum palati is not square, but turned into elegant arches; and, from the middle of the arches of the palate, hangs down the UVULA, so named from its resemblance to a grape. It is a large, soft, and glandular papilla, peculiarly irritable and moveable, having in it muscular fibres, and hanging from the moveable soft palate. It seems to hang as a guard over the fauces, and, by its sensibility, in a great degree governs the operation of these parts. It is also part of the organ of the voice.

The ARCHES OF THE PALATE OR FAUCES descend on each side from the velum palati. They are muscular fibres, covered with the soft vascular and follicular membrane of the fauces.* There are two on each side. These arches stand at some distance from each other, so that the isthmus of the fauces resembles the double-arched gateway of a citadel, or rather the arched roof

* See Vol. I. Constrictor Isthmi faucium and Palato-pharyngeus.

of a cathedral, with the uvula hanging as an ornament from the central union of four semicircular arches; for the arches which are apart below are joined above.

Behind the soft palate is the cavity of the fauces, and into that cavity there are openings from the nose. The use of the velum is, that, in swallowing, it may be drawn up like a valve upon the posterior opening of the nose; and there being, at the same time, an action of the arches of the palate, the whole are brought into a funnel-like shape, which directs the morsel into the pharynx and gullet. In this action, the direction of the food assists the valvular action of the velum; but, in vomiting, the nose is assailed with the contents of the stomach. The velum also is a principal part of the organ of the voice; it divides the air which issues from the lungs, and directs it either into the cavity of the mouth or nose.

Amygdalæ. — Betwixt the arches of the palate, on each side, lies a large oval gland of the size and shape of an almond. These are the tonsils or amygdalæ. The amygdala is a mucous gland; it is loosely covered with the investing membrane of these parts: its surface is seen, even in a living person, to be full of large cells like lacunæ; these communicate; and into these the lesser mouths of the ducts open. On a narrower inspection of the amygdala, we may describe its structure thus: within the arch of the palate, and before the arch of the fauces, there is a fossa of an oval shape, and on the surface of the membrane a number of cells open like the mouths of veins. When the arches and the amygdala are dissected out, behind these holes we feel a gland, as it were one solid body; but on further dissection from behind, the cellular membrane being taken away, instead of one large gland, there are a number of lesser ones. These glands discharge their secretions into the oblique passages just described; and from these lacunæ the mucus is pressed out when the morsel is pushed backward. From the loose texture, and from its being a vascular and secreting body, exposed to the immediate vicissitudes of weather, the amygdala is often inflamed, and then it impedes the action of the sur-

rounding muscular fibres in the action of deglutition. The use of the amygdala is evidently to lubricate the passage of the throat, and facilitate the swallowing of the morsel; and, for this reason, are the mouths of its ducts cellular and irregular, that they may retain the mucus until ejected by the action of deglutition. In this operation, the amygdalæ are assisted by numerous lesser glands, which extend all over the arches of the palate and pharynx.

OF THE SENSE OF TASTING.

On the surface of the tongue are to be observed many papillæ *; in which the extremities of the gustatory nerve terminate: they are the organs of the sense of tasting. These papillæ arise from the true skin of the tongue; they are extremely vascular; they are covered by the rete mucosum, and a very fine cuticular sheath. These papillæ are to be seen on the point and edge of the tongue, as pretty large vascular soft points which project from an opaque and white sheath. If you take a pencil and a little vinegar, and touch or even rub it strongly on the surface of the tongue, where those papillæ are not, the sensation only of a cold liquid is felt; but when you touch one of these papillæ with the point of the brush, and at the same time apply a magnifying glass, it is seen to stand erect and rise conspicuously from its sheath, and the acid taste is felt to pass as it were backward to the root of the tongue. The exquisitely sensible papillæ are placed only on the point and edge of the tongue; for the middle of the tongue is rough and scabrous, not to give the sensation of taste, but to break down the solid morsel against the roof of the mouth, and press the sapid juice from it, so that it may run over the edge of the tongue. The more delicate and vascular papillæ would be exposed to injury

* Albinus Ann. Acad. lib. i. c. xv.

if situated on the middle of tongue. Before we taste, the substance dissolved in the saliva flows over the edges and point of the tongue, and then only comes in contact with the organ of taste.

It would appear that every thing, which affects the taste, must be soluble in the saliva; for without being dissolved in this fluid, it cannot enter readily into the pores and inequalities of the tongue's surface.

We have already noticed, that by the peculiar form of the larger papillæ at the root of the tongue, the fluids lodge, and the gratification of the palate is prolonged. A curious circumstance, in the sense of taste, is its subserviency to the act of swallowing. When a morsel is in the mouth, and the taste is perfect, our enjoyment is not full: there follows such a state of excitement in the uvula and fauces, that we are irresistibly led to allow the morsel to fall backward, when the tongue and muscles of the fauces seize upon it with a convulsive grasp, and convey it into the stomach; it is only then that the measure of enjoyment is full. Were not this appetite of the throat and uvula connected with the action which impels the food into the stomach, the complete enjoyment of the sense of taste alone would satisfy, and would have rendered unnecessary the disgusting practice of the Roman gourmand, who forced himself to vomit that he might resume the enjoyment of eating. But, as it is, the connection of the stomach and tongue is such, that the fulness of the stomach precludes the further enjoyment of the sense of taste. The senses of smelling and taste have their natural appetites or relish; but they have also their acquired appetites, or delight in things which to unsophisticated nature are disagreeable: so that we acquire a liking to snuff, tobacco, spirits, and opium: "Nature, indeed, seems studiously to have set bounds to the pleasures and pains we have by these two senses, and to have confined them within very narrow limits, that we might not place any part of our happiness in them; there being hardly any smell or taste so disagreeable that use will not make it tolerable, and at last, perhaps, agreeable: nor any so agreeable as not to lose its relish by constant use. Neither is

there any pleasure or pain of these senses which is not introduced or followed by some degree of its contrary which nearly balances it. So that we may apply the beautiful allegory of Socrates: that "although pleasure and pain are contrary in their nature, and their faces look different ways, yet Jupiter hath tied them so together, that he who lays holds of the one draws the other along with it."

OF THE SKIN AND OF THE SENSE OF TOUCH.

OF THE SKIN.

THE skin may be divided, by the art of the anatomist, into four laminæ or membranes, distinct in texture and appearance, and use, viz. the *cuticle* or *epidermis*; the *corpus mucosum*, or reticular tissue; the *cutis vera*, *dermis*, *corium*, or true skin: but from the surface of this last there is separated a *vascular membrane*, below which is the surface of the true skin; lastly, we may enumerate the tela cellulosa as constituting a part of the general integument, giving lodgment to the glands of the skin and to the bulbs of the hairs.

The CUTICLE, or EPIDERMIS, or SCARF SKIN, is the most superficial of these layers: it is a transparent and insensible pellicle which serves, in some degree, to resist the impression of external bodies on the surface of the body, and to blunt the otherwise too acute sensation of the cutis vera.* In man it is very thin, unless in those parts which are exposed to the contact of hard bodies,

* It is unaccountable that so great a man as Morgagni could suppose the cuticle to be the mere effect of air and pressure on the surface of the true skin. Adversar. Anatom. III. 3.

as the palms of the hands and soles of the feet. The thickness of the cuticle there, however, is not altogether the effect of labour and walking, but there is even in the early fœtus a provision for the defence of the skin of the feet, by the supply of a thicker cuticle. When the cuticle is drawn from its foot, that part upon the sole is white, opaque, and thick, whilst, in the leg, it is transparent and more delicate.* This is also particular, that by labour or continued pressure on the cuticle it does not abrade and become thin and tender, but thicker, harder, and the part more insensible, so as even to acquire a horny hardness and transparency. Of this we have an example in the hands of smiths and other workmen, and in a remarkable manner in the feet of those who have been accustomed to walk barefoot on the burning sands. It is thus a protection to the foot in a state of nature. But if the skin be too much or too quickly exerted, instead of forming additional layers of cuticle, a serous fluid is thrown out from the true skin, which separates the cuticle in blisters; and this over-action of the skin will throw off the cuticle, as we see to be the consequence of the irritation of plasters or cataplasms, scalding water, exanthematous diseases, erysipelas, and mortifications, &c. When the foot comes to be unnaturally pinched in shoes, the hard leather works perpetually on a point of the toes, and blisters the feet; but if in a lesser degree and longer continued, it excites the formation of cuticle in the skin below, which, thrown outward by succeeding layers of cuticle, at last forms a corn or clavus, and which, like a small nail, has a broad head with a conical point shooting into the tender skin.†

The cuticle is perforated by the extremities of the perspiring and absorbing vessels, and by the ducts of the glands of the skin, and by the hairs. Indeed, when the small pores of the skin or foramina are examined narrowly, the cuticle is seen to form sheaths which enter

* Albini Annot. Acad.

† De clavo pedis, vide Albini Acad. Annot. lib. vi. cap. vi. et vide tab. ii. fig. 1.

into them, and which, when torn out, are like little tubes having a perforated point; for when, by maceration, the cuticle is separated from the skin, as we draw it off we see little processes of the cuticle, which enter into the pores of the skin.

In the dead body the cuticle may be separated by permitting putrefaction to go on, and for this purpose the skin is put in maceration*: Ruysch separated it by extending a portion of skin and pouring boiling water upon it.† Vesalius and Malpighi practised the coarser way of carrying a red hot iron near the skin.

Mr. Cruickshanks enumerates three classes of processes of the cuticle: there appear evidently two. The first lines the pores through which the hairs pass: these are the longest. The second class is easily distinguished on the inside of the cuticle which covers the palms of the hands or soles of the feet, or indeed on any part of cuticle; and they appear in regular order on those parts of the cuticle which correspond with the parallel or spiral ridges of the cutis: these enter into the pores of the true skin. The surface of the cuticle is uniform next the skin; but, on the outer surface, it is rough and squamous. These squamæ are the portions of the cuticle, which, breaking up, are rubbed off; for there is a perpetual change, by the formation of new cuticle under the old, and the abrasion or desquamation of the old surface.

When I say that the cuticle is uniform, I must not forget to speak of the regular lines observable on both its surfaces, and which are especially observable on the tips of the fingers, and which are a very particular part of the organ of touch.

The ulcerative process has no power over the cuticle, so that when the matter of an abscess has reached the cuticle, its progress is stopped until the cuticle is burst by the distention. This is one reason of the greater pain of abscesses in the soles of the feet and palms of the hand, where the cuticle is very strong.‡

* Santorini Observ. Anat. cap. i. § i.

† De hum. C. fabrica, lib. ii. c. 6.

‡ See Hunter on Blood and Inflam. p. 469.

OF THE STRUCTURE AND GROWTH OF THE NAILS.

The NAILS are naturally connected with the cuticle, for they remain attached to it: in exanthematous diseases, when the cuticle exfoliates, the nails are also pushed off; and in death they both separate from the true skin by maceration and beginning putrefaction. The nails are to give firmness and resistance to the points of the fingers. Although they take a very universal adhesion, it is chiefly from the root that they grow and shoot out to the points of the fingers, to which they adhere firmly. Over the root of the nail the cuticle projects, and under it the rete mucosum is extended; and under this, and defended by it, are the papillæ of the skin.

Like the cuticle, the nails are without vessels or sensation: they are undergoing a perpetual growth, by their roots, and are worn down by labour. When cherished, they grow to an amazing length, and curve a little over the points of the fingers. It was supposed that the nails were formed by the extremities of the tendons, which, extending beyond the flesh, were dried and hardened*; and the celebrated Albinus describes the nail as formed by the conversion of the papillæ which lie under it†: they are more properly conceived to be a continuation of the epidermis.‡

We cannot believe, even on the authority of Albinus, that the nervous filaments which lie fasciculated under the nail are converted into the nail, merely because the under surface of the nail is reticulated like these filaments. For it is evidently reticulated like the soft filaments, in order to give lodgment to them, to have a corresponding surface with them. The nails differ from the cuticle in not scaling or exfoliating like it, but in growing from a root like a hair.

OF THE HAIRS.

The hairs grow from a bulbous root, seated in the cellular membrane. This bulb is vascular, and has con-

* Riolanus.
† Annot. Acad. vol. i. lib. ii. cap. iv.
‡ Winslow.

nection, by vessels, with the cellular texture. It consists of a double membrane; the outer is a kind of capsule which surrounds the other, and stops at the pore in the skin, and does not form part of the hair. Betwixt these capsules, there is a cellular tissue, and the space is commonly found filled with a bloody fluid. In the bottom of the inner sac, there is a small body, called monticule by Duverney, from which the hair is seen to arise; and if this is left when the bulb of the hair is pulled out, the hair will be regenerated.

The root of the hairs, says Winslow, is covered by a strong white membrane, which is connected with the skin and cellular membrane. Within the root, there is a kind of glue, some fine filaments of which advance to form the stem, which passes through the small extremity of the bulb to the skin. As the stem passes through the root, the outer membrane is elongated in form of a tube, which closely invests the stem, and is entirely united with it. And many authors agree, that the hair does not perforate the cuticle, but takes from it a vagina which accompanies it in all its length.*

The hair serves as a distinction in the human tribes. The European has the longest hair, next to him the Asiatic, then the American, and lastly the African.† A common opinion is entertained that hair on the body is a mark of strength; but I have observed our famous boxers, when in high condition, are smooth, fair, and clear in the complexion of their bodies; while men of a dark sallow hue are generally hairy on the trunk and shoulders. Betwixt hair and wool, or betwixt the hair on different parts of the body, there is no distinction in the anatomical structure. In the growth of hair and wool, however, there is a difference. They are both produced annually; but wool is shed at once, and leaves the animal bare, whilst the hair falls off gradually, and the young and the old hairs are together growing at the same time. Hair is of uniform thickness in its whole

* Albinus Acad. Annot. Lvi. cap. ix. and Morgagni Adversar. et Epist. An. iii. § 4.

† Mr. White of Manchester tells us he has seen a lady with hair six feet in length; — a Prussian soldier, whose hair trailed on the ground.

length; whereas wool is variable in the thickness of its filament: — further, it has been found that the thicker part grows during the warmer times of the season; that it is thicker in summer, and finer in the spring and autumn. This shows us how the fleece becomes coarse and hairy in a warm climate.

RETE MUCOSUM.

The rete or corpus mucosum, or Reticulum Malpighi, lies between the cuticle and surface of the true skin. It is a mucous layer, pervaded by the little fibrillæ passing betwixt the skin and the cuticle. I consider it as a soft bed to envelope and preserve the papillæ of the skin, and as intended to become cuticle in due succession. It was considered, by Albinus, as of a nature adapted to imbibe the fluids through the cuticle, and as a production of the epidermis. Meckèl believed it to be only a mucous fluid, inspissated into the form of a membrane; and that it was dissolved by putrefaction, while the skin and cuticle remained firm. It is the seat of colour in the skin, and is of a white transparency in the albino, and in the inhabitants of temperate climates. It is black in the negro; copper-coloured in the mulatto; yellow in the Egyptian.* From the experiments of Priestley, on the effects of coloured cloth in absorbing light, we should argue that the blackness of the negro's skin was ill calculated for enduring the heat of warm climates. But it has been, on the other hand, argued that the black colour facilitates the radiation of heat, and that, as the heat of

* Malpighi de Sede Negridinis in Ethiope. It has appeared to me that there was a great deal of colour in the cuticle of the negro, and so Morgagni, "negricante et fusco colore infectas." Adversar. II. Animad. IV. See also Blumenbach de Generis Humani Varietate. The colour of the skin belongs to tribes, and is only in a certain degree affected by climate. Humboldt, Essaie Politique sur la Nouvelle Espagne, observes that climate, which has such an effect on Europeans, has little or none on the Indian complexion; tribes of a temperate climate are darker than those inhabiting a province less cool and temperate. The Indians on the tops of the Andes are as dark as the inhabitants of the plains. Humboldt also asserts (contrary to Volney) that, in the provinces of Spanish America the children of Indians are copper-coloured from the moment of their birth.

the body is greater than the heat of the atmosphere, the blackness will, upon the whole, tend to preserve the body cool. The rete mucosum changes it shades of colour in Europeans, from the effect of light; but this tanning seems to have no strict resemblance to the permanent colour of the negro's skin. It soon reaches its maximum by the influence of the sun, and soon it wears off again. And this degree of blackness does not attach to the offspring.* When the rete mucosum is destroyed by ulceration, it is imperfectly regenerated, and does not possess its former colour. In a negro, the inner surface of the rete mucosum is blacker than the outer surface; the inner surface of the cuticle is softer and darker than the outer surface.† Mr. White argues, that if this blackness were the effect of the sun, that part most exposed would be the blackest. But though I agree with him in thinking that the blackness of the negro is not owing to climate, yet I see this argument of his is incorrect; for it is not the direct influence of the sun which tans; no such effect comes of exposing dead skin; it is the excitement of the living vascular surface in the formation of new matter, or the discharge of colouring matter into the rete mucosum.

While the rete mucosum has its peculiar use of defending the delicate surface of the papillæ of the skin, I conceive it to be undergoing a perpetual change; to be thrown off in succession from the vascular surface of the skin, and in its turn to form the cuticle by its outer layers. The inner surface of the rete mucosum is softer and more pulpy; the outward surface more allied to the cuticle, which gives occasion to Mr. Cruickshanks to say it is double.

* See the Gradation in Man, by Charles White of Manchester. Some have said that extreme cold also tans the skin, as the Laplanders, the Esquimaux Indians, and Greenlanders, are dark; opposed to this, we find the Finlanders and Norwegians fair beyond other Europeans. There is much in the habits of life: a painter will not find his carnation tints amongst the poor, nor in the skin of a Highlander — yet where so pure as in the Highland lady?

† For opinions regarding the cause of colour in the skin, see Albinus de Sede et Causa Coloris Æthiopum, Ludg. Batav. 1737.—Haller Element. Physiolog. page 20.—Blumenbach de Generis Humani Varietate Nativa, Got. 1795, page 122., and note.

VASCULAR MEMBRANE OF THE TRUE SKIN.

Under the rete mucosum, and on the surface of the skin, there is a soft vascular membrane, which is still above the porous and glandular true skin. It was first demonstrated by injections in subjects who had died of small-pox, and it is so much strengthened by other inflammatory actions of the vessels of the skin, as to be capable of demonstration. It was at first supposed that this vascular membrane was the rete mucosum successfully injected; but afterwards it was found, that it was distinct from the rete mucosum.* Mr. Cruickshanks conceives that it is cuticle in its state of formation, and that the rete mucosum is in fact a cuticle advancing to the state of perfect maturation. I should rather believe that this is a vascular surface, not changeable, nor losing its vascularity, to be thrown off in form of rete mucosum: but, in itself, the organized surface, which is to secrete the rete mucosum, and which secretion does in succession become cuticle. This vascular surface of the skin, for such I must suppose it, (although it be capable of being separated by long maceration and putrefaction, into something like a distinct membrane,) is the seat of the small-pox pustule, and probably of all other cutaneous diseases.†

Thus there are three laminæ above the true skin, distinguished by their character; the cuticle, the rete mucosum, and the vascular membrane: but as some have divided the rete mucosum into laminæ, Mr. Cruickshanks has separated two vascular layers from the surface of the skin. They who are fond of such minute subdivisions, may thus enumerate five laminæ

* Mr. Baynham, who discovered this vascular surface, conceived that he had injected the rete mucosum. Ruysch and others mentioned by Albinus, supposed they had injected the cuticle when most probably they had torn off the vascular membrane, or, as Albinus alleges, Acad. Annat. lib.vii. c.iii. in taking off the cuticle they had torn up the vascular papillæ along with it.

† Of the slough of the small-pox pustule, see Dr. Adams's Morbid Poisons. Appendix.

or membranes, before coming to the porous surface of the true skin.

OF THE TRUE SKIN.

The true skin is the dense, elastic, and vascular membrane which is under these outer layers already treated of. It consists of a net-work of firm filaments, having in their protection sebaceous glands, exhalent and absorbent vessels, nerves, the papillæ or organized extremities of the nerves, and the roots of the hairs. These are sufficient to give it both some substance and firmness. While it has firmness, strength, and elasticity to defend the body, it is also an organized surface, performing important functions in the economy; and the healthy condition of the system depends upon it nearly as closely as on the action of the lungs or of the surface of the intestines.

The skin is dense on the outer surface, while the internal layers are loose, and gradually degenerate into the cellular substance. Our soldiers and sailors have a way of marking their skins with gunpowder or with vermillion, which is indelible. They prick the skin and insert the colouring matter into it, where it remains without producing inflammation, and unabsorbed. But this is no proof of the unchangeable nature of the skin as regards its colour, or whatever else may distinguish the nations and tribes of man.*

On narrowly observing the surface of the skin, we find it irregularly porous. Some of these are the ducts of sebaceous glands, which are lodged in the skin. They transmit the hairs also, and are the perspiring, and, probably, the absorbing pores; or, at least, within these larger pores the absorbing and transpiring vessels terminate. These pores are most remarkable about the nose, mouth, palms of the hands, and soles of the feet. Into these pores of the true skin, as we have mentioned, little sheaths of the cuticle enter, and through these

* I allude to the ingenious Essay of the Rev. S. S. Smith of the American Philosoph. Society, on the Causes of the Variety in the Human Complexion and Colour.

sheaths the perspiring matter must consequently escape: but perspiration is the action of living parts: in death, the action of the perspiring vessels ceasing, the pores of the cuticle are no longer pervious to the fluids, and there is no perspiration or exudation through them, even when the dead surface is exposed to heat, it dries only where the cuticle is off.

OF THE ORGAN OF TOUCH.*

The villi of the skin project above its surface, like the pile of velvet. They vary much in size, and in some places are very much prolonged. They conduct the sensible extremities of the cutaneous nerves to form the organ of the sense of touching†; I see that these sentient filaments are very vascular at their extremities. When the hand is minutely injected, and there seems a general blush of redness over it: when the cuticle is taken off, and we examine the villi with a powerful magnifying glass, their extremities are seen bulbous and red. We know that even in nerves there is no sensibility without blood be supplied, and I look upon this high degree of vascularity as a provision for great sensibility.

These fine filaments are placed in the softest bed possible. Examine the minute ridges of the cuticle, and you may distinguish them to be quite regular; the ridge which is prominent externally corresponds with a depression or minute sulcus within. In these sulci, or in the interstices of the ridges of the cuticle, there is a soft matter in which the villi lie secure, yet ready to receive the impression made through the insensible cuticle.

Of the nature of the sensation conveyed by the nerves of the sense of touch we are as ignorant as of that conveyed by the other nerves. Some are accustomed to consider this as an inferior sense, for no better reason

* Albinus Dissertatio de Sede et Caus. Color. Æthiop. Malpighi, Exercit. de Tact. Organ.

† Vide de Papillis Cutis. Albin. Ac. Annot. lib. vi. c. x. and Ruysch.

than that it is more common to the surface of the body, whereas it is the most important, and that which ministers to the other senses and to our necessities most of all: — it is the sense necessary to the existence of every living creature. Nor is it, as they suppose, a universal sense. It is as much limited to the external surface of the body as the sense of vision is to the eye.

Nay more, it is that sense which gives correctness to all the others, at least if we are right in attributing the perception of hardness, softness, solidity, figure, extension and motion, to the exercise of this sense. If the sense of touch be that change arising in the mind from the application of external bodies to the skin, then certainly the organ has high exercise, and is of all the senses the most valuable. But it appears to me that these qualities, of hardness, softness, solidity, figure, extension and motion, would be known to us, although we had no nerves in our fingers at all, by what I would call the muscular sense. We may acquire a conception of these qualities by moving our body or our members, by pressing upon an object and feeling the resistance it occasions. Much might be said on this subject, but it is evident that these two senses, of motion or action, and of feeling, must be closely allied and mutually useful to each other.

FUNCTION OF THE SKIN.

The function of the skin has a very extensive connection with the due performance of those of the internal organs of the animal economy.

The perspired matter from the skin consists principally of water and carbon. The carbonic acid produced in the process, is by the union of the carbon with the oxygen of the atmosphere. The perspired fluid holds also in solution several salts, and excrementitious matter of animal substance.

Besides the insensible perspiration, there is an oily exudation from the glands of the skin, which appears to be useful in giving pliancy and softness to the scales of the cuticle. This oily secretion is copiously secreted

in the negro; and it appears as a means of protection against the powerful influence of the sun, in as much as it prevents the cracking and breaking of the squamæ of the cuticle. It preserves the skin soft and perspirable. The softness of the negro's skin is remarkable; and this softness and coolness of the skin is observable in all the degrees of propinquity to the negro.

It has been long observed that the surface of the body, immersed in water, gave out bubbles of air. Lavoisier found that this air precipitated lime water. Cruickshanks, Abernethy, Jurin, continued these experiments illustrative of this function of the skin in giving out carbonic acid; but these have been overthrown by Professor Woodhouse of Philadelphia, who proved that the air so collected upon the surface was attracted from the water and not exhaled by surface.

Nevertheless carbon is discharged by the skin, and the quantity is found to depend on the vigour of circulation, and of the constitution; and when discharged from the skin as I have said, the attraction of the oxygen of the atmosphere forms the carbonic acid. Thus the function of the skin is brought to resemble, in the most essential particular, the function of the lungs; and I believe all animal surfaces whatever will be found to partake of this function, the discharge of the useless carbon from the system.

The powers of the human system are, in all respects, superior to that of brutes; and the provision for the human body inhabiting the different climates of the globe, is most particular. It has been proved that man, for a short time, can support existence in a heat of 260° of Fahr. It is proved, that while he can live in indulgence under the line, he can inhabit a country so cold as to drive away the white bear of the polar regions. A ship's crew have wintered in 76° of northern latitude, and the powers of the living body sustained life while spirits and mercury were frozen.

Although there are experiments by Dr. Fordyce, which prove that animals possess a power of resisting heat independent of perspiration, still, undoubtedly, the free or checked perspiration of the surface is a means

of equalizing the temperature of the body. According to the activity of the circulation is the heat of the body, and according to the activity of the circulation is the perspiration in health. By this perspiration, and the change of the perspired fluid unto vapour, the heat of the body is carried off. In a cold atmosphere, perspiration ceasing, the vital heat is retained; in a warm atmosphere, the perspiring action being excited, the heat of the body is prevented, or rather carried off.

The authorities are contradictory in regard to the absorption by the surface, unaided by friction, abrasion, or ulceration. *

The more important function of the surface is to be contemplated in its effect on the general activity of the vascular system, and in the vicarious action which takes place betwixt it, the stomach and intestines, and the kidney and lungs. The similarity of function performed in the lungs and by the skin, would lead us to attend to the injury of the former by the impression of cold on the surface, and the checked perspiration. The fact that perspiration is altered in degree by the progress of digestion, would lead us to attend to the many occasions in which we see the disorders of the viscera effecting changes on the skin; the imperfection of the function of perspiration, when digestion and the function of the viscera are deranged, would lead us not only to mark the symptoms of internal disease on the skin, but to take the means of exciting the latter as a remedy for the former. In the same manner will the secretion of the kidney be influenced by the state of the skin and of perspiration: need I add that the health and strength of the circulation, and of course the health of all the functions, is influenced by the excitement of the skin? Some practitioners take the stomach, and others the bowels, and others the liver, on which they harp continually; let any one take the skin as his object of care, and his practice will have equal success, his cases and facts become soon as numerous, while his connection with general science will be more intimate; and if he

* Rollo on Diabetes, Dr. Currie, Abbe Fontana, Dr. Watson.

introduce his system by showing that health is enjoyed when the various functions, which together form the animal economy, are perfect, and that one function cannot be in health unless the whole be also, he will, in my opinion, have better claims to public favour than any who have yet flourished in it by promulgating doctrines in regard to the functions and diseases of individual parts.

EXPLANATION

OF

THE PLATES.

Explanation of Plate I.

Fig. 1.

The eye, with the cornea cut away, and the sclerotic coat dissected back.*

a. The optic nerve.

b. The sclerotic coat dissected back, so as to show the vessels and nerves of the choroid coat.

c c. The ciliary nerves seen piercing the sclerotic coat, and passing forward to be distributed to the iris.

d. A small nerve passing from the same source to the same destination, but appearing to give off no branches.

e e. Two of the venæ vorticosæ.

f. A point of the sclerotic coat through which the trunk of one of the veins had passed.

g. A lesser venous trunk.

h. The orbiculus ciliaris of Zinn; the ciliary ligaments of others.

i. The iris.

* See Zinn, Tab. iv.

k. The straight fibres of the iris.

l. A circle of fibres or vessels which divide the iris into the larger circle k, and the lesser circle m.

m. This points to the lesser circle of the iris.

n. The fibres of the lesser circle.

o. The pupil.

FIG. 2.

A dissection of the coats of the eye, as they appeared when hung in spirits.

A. The OPTIC NERVE.

B. The SCLEROTIC COAT folded back.

C. The CHOROID COAT hanging by its attachment to the sclerotic coat.

D. The vessels of the RETINA seen as they appeared suspended in the fluid; the medullary part of this coat being washed away.

EXPLANATION OF PLATE II.

In this plate, the anatomy of the bones of the human ear is explained.

FIG. 1.

We have here the bones which form the chain betwixt the membrane of the tympanum and the membrane of the foramen ovale.

A. The MALLEUS.

B. The INCUS.

C. The STAPES.

D. The OS ORBICULARE, which forms the articulation betwixt the incus and stapes.

Fig. 2.

In this figure we have a view of the inside of the temporal bone, the petrous portion being broken away: we see the cavity of the tympanum, the membrane of the tympanum, and the chain of bones.

A. The groove for the lodgment of the lateral sinus.

B. The hole in the sphenoid bone for the passage of the artery of the dura mater.

C. The petrous portion of the temporal bone.

D. The irregular CAVITY of the TYMPANUM laid open by the breaking off of the petrous part of the temporal bone.

E. The MEMBRANE of the TYMPANUM closing the bottom of the meatus auditorius externus.

F. The MALLEUS, the long handle of which is seen to be attached to the membrane of the tympanum E.

G. The INCUS, united to the great head of the malleus F.

H. The stapes, which is seen to be articulated with the long extremity of the incus through the intervention of the os orbiculare.

Fig. 3.

Shows the division of the temporal bone into the squamous and petrous portions.

Fig. 4.

A. The SQUAMOUS PART of the temporal bone.

B. The CIRCULAR RING, which forms the meatus auditorius externus in the child.

C. The ZYGOMATIC PROCESS.

D. Cells which afterwards enlarge into those of the mastoid process.

Fig. 5.

The petrous portion of the bone, with a view of the tympanum.

A. The CAVITY of the TYMPANUM.

B. MASTOID CELLS.

D. The FORAMEN OVALE, into which the stapes (see fig. 1. C. and fig. 2. H.) is lodged.

E. The more irregular opening of the FORAMEN ROTUNDUM.

Fig. 6.

Represents the labyrinth of the human ear, with the solid bone which surrounds it cut away.

A. The FORAMEN OVALE.

B. The three SEMICIRCULAR CANALS.

D. The COCHLEA.

E. The tube which conducts the portio dura of the seventh pair through the temporal bone.

Fig. 7.

Explains the manner in which the lamina spiralis divides the cochlea into two scalæ, and the opening of the one scala into the common cavity of the vestibule, and the termination of the other in the foramen rotundum.

A. The bone broken, so as to show the cavity of the tympanum.

B. The FORAMEN OVALE.

C. Cellular structure of the bone.

D. The FORAMEN ROTUNDUM.

E. One of the SCALÆ of the cochlea, which is seen to terminate in the foramen rotundum.

F. The other scala, which is seen to communicate with the vestibule.

EXPLANATION OF PLATE III.

These two figures are taken from the beautiful plates of the Professor Scarpa, and illustrate the soft parts con-

tained within the osseous labyrinth, and the distribution of the nerves.

FIG. 1.

There is seen the membranous semicircular canals, their common belly, and the distribution of the acoustic or auditory nerve.

a. The AMPULLA of the superior membranous semicircular canal.

b. The SUPERIOR MEMBRANOUS SEMICIRCULAR CANAL.

c. The AMPULLA of the external membranous canal.

d. The other extremity of the external canal.

e. The AMPULLA of the posterior membranous semicircular canal.

f. The POSTERIOR SEMICIRCULAR CANAL.

g. The common canal of the superior and posterior canal.

h h. The sac common to the membranous semicircular canals, viz. the ALVEUS COMMUNIS.

i. The body or trunk of the ACOUSTIC NERVE.

k. The larger branch of the nerve.

l. A filament of the nerve to the sacculus vestibuli.

m. The lesser branch of the acoustic nerve.

n. A filament to the cochlea.

oo. Filaments of the larger branch of the acoustic nerve to the ampullæ of the superior and exterior semicircular canals.

p. The expansion of the nerve on the common alveus.

q q. NERVUS COMMUNICANS FASCIEI OF PORTIO DURA.

r. The beginning of the spiral lamina of the cochlea.

s. The osseous canal of the nerve, which forms part of the foramen auditorius internus.

t. The COCHLEA.

FIG. 2.

The distribution of the nerve in the cochlea, seen by a section of the internal auditory canal and cochlea.

a. The SUPERIOR OSSEOUS SEMICIRCULAR CANAL.
b. The posterior osseous semicircular canal.
c. The external osseous semicircular canal.
d. The bottom of the great FORAMEN AUDITORIUM INTERNUM.
e. The trunk of the great acoustic nerve.
f. The ANTERIOR FASCICULUS of the acoustic nerve.
g. A plexiform twisting in the anterior fasciculus of the nerve.
h. A gangliform swelling of the nerve.
i. The greater branch of the anterior fasciculus.
k. The lesser branch.
l. A filament of the anterior fasciculus to the hemispherical vesicle of the vestibule.
m. A branch to the beginning of the lamina spiralis.
n. The POSTERIOR FASCICULUS of the acoustic nerve.
o. The filaments about to enter the tractus spiralis foraminulosus.
p. These nerves seen upon the modiolus.
q q. The filaments of the nerve passing forward betwixt the two planes of the lamina spiralis.
r r. Their termination on the soft part of the lamina spiralis.
s. The nerves expanded on the second gyrus of the modiolus.
t t. u u. Their further distribution on the lamina spiralis.
v v. The INFUNDIBULUM.
x y. The last turn and termination of the lamina spiralis in the infundibulum.

THE

ANATOMY

OF THE

VISCERA OF THE ABDOMEN.

THE

ANATOMY

OF THE

VISCERA OF THE ABDOMEN.

INTRODUCTION.

VIEW OF THE SYSTEM OF THE VISCERA, AND OF THE STRUCTURE OF GLANDS.

In this last division of the work we have to comprehend the anatomy and functions of the several viscera of the abdomen and pelvis: we must consider them not only as individual parts, but as connected together, and as forming with the lymphatic and circulating systems of vessels that chain of dependence and relation which constitutes the animal economy. It is necessary to take here a general view of the economy of the intestinal canal and absorbing system, including, at the same time, something of the history of opinions regarding secretion and the structure of glands. It will be understood, that these introductory observations are meant only to combine the several parts, and to prevent that manner of description, which is necessary to accuracy and minuteness, from leading us to consider the several parts as distinct and insulated.

An animal body is never for a moment stationary: the remotest part is in action, and is suffering an incessant change. From the first moment of animal existence a revolution is commenced: we, by slow degrees, advance

in activity and strength, and ripen to maturity; but by as slow and as sure gradations we decline to feebleness and infirmities. The more rapidly animals advance in the first stage of their progress, so is their decline proportionally rapid.

But it is not in observing the changes of the animal body from youth to age that the operations of the economy appear the most interesting. It is when we find the living body to consist of parts performing a variety of functions, and these connected and mutually dependent; when we see the circulating fluid throwing out fluid and solid secretions to build up and support the body, which is in incessant and daily decay. Again, our admiration must be strongly excited when we observe the system to consist of fluids and solids, and the existence of the animal to depend upon the balance of different powers, the fluids separating and combining in new affinities, and forming the various secretions; and the solids possessing life and action, and controlling the affinities and influencing the combinations of the circulating fluids. Forgetting that animation is the essential character of living bodies, that it influences the chymical affinities, and varies the attraction of particles, physiologists have too much endeavoured to explain the phenomena of animated nature by illustrations, formerly drawn from mechanics and hydraulics, and in the present day from chymistry.

In a body in which there is life, there is a perpetual waste; first, by secretions, which for particular purposes are thrown into the cavities, and afterwards carried out of the body entirely, by the excretions of the kidney, by the perspiration from the surface, the exhalation by the lungs, the secretions of the intestines. But more than this, there is a decomposition of the solids of the body which are carried into the circulating fluids, and finally dismissed from the system. Lastly, we observe, that even the powers of muscular motion, nay, the powers of the mind and of the senses, are exhausted by exercise, and renovated through the influence of the circulation. The continued action of a muscle is followed by feebleness, and the continued impression of the rays of light

exhausts the retina, so that the object becomes first faint and then vanishes; and these, and all the other powers peculiar to life, are supported by means of the circulating arterial blood.

Since there is waste of the solids and fluids, and exhaustion of the energies of the system, so also must there be a source of supply, and means of renewing its activity, and there must be a perpetual motion in the particles of the living frame. Accordingly, animals have appetites requiring the supply of food and drink, and the calls of hunger and thirst stand in relation to the necessities of the body. When food is received into the first passages, there is thrown out from the stomach a fluid which dissolves it, changes its properties, and is itself essentially altered. The work of assimilation is thus begun. As this converted fluid takes its course through the intestines, it is more and more changed; more nearly assimilated to the nature of the fluids of the animal; and having still additional secretions united to it, particularly the bile, it is by these means purified from the grosser parts, and fitted for absorption. This fluid, which is now called chyle, is absorbed by a particular and appropriate system of vessels, which, from their conveying this white and milky-like fluid, are called the lacteals. The lacteal vessels carry the chyle to the thoracic duct, the trunk of the absorbing system; but not directly; for the chyle is deposited in the mesenteric glands, from which it is again absorbed and carried forward. Or if we suppose these glands to be merely convoluted vessels, its flow is at least delayed, so that it is not at once thrown into the mass of circulating fluids.

We find, then, that the stomach performs digestion, and the spleen, we will venture to affirm, is subservient to it. The secretion of the liver we find to prepare the chyle for absorption, while, at the same time, it is the peculiar stimulus to the intestines. The pancreas pours out a fluid which tempers the acrid bile. The superior part of the intestinal canal absorbs the nutritious fluid or chyle, while the gross remains of the food move on

to be deposited in the great intestines. The great intestines are not only receptacles, but form, at the same time, an extensive secreting and absorbing surface useful in the economy.

The lacteal vessels, which take up the chyle, are but branches of the system of absorbents — which is a system consisting of two great divisions, the lacteals and lymphatics: the first receiving the nutritious fluids from the intestinal canal, and the latter being absorbents, taking up the fluids which have been thrown out upon the cavities and surfaces of the body; and we presume upon their absorbing the solid parts of the body also. Thus the new fluids, rich in supplies, are mingled with those which are fraught with the waste and decomposition of the system. The thoracic duct, the trunk of this system, conveys these fluids thus mingled together into the right side of the heart, where they are received into the vortex of the circulating red blood. These fluids, now agitated and wrought up with the blood in the cavities of the heart, are sent through the circulation of the lungs, and submitted to the influence of their action and the exposure to the atmospheric air.

When chyle is formed in the stomach and intestines, it is observed to consist of albumen, serum, globules, and salts; but the change which it may undergo by its reception into the lacteals, its being deposited in their glands, its mingling with the lymph, its agitation in the heart, have not been observed, though it is natural to suppose, that by degrees it is assimilated in its nature to that of the circulating blood, and does at last become perfectly similar by the operation of the lungs.

By the exposure of the circulating fluids to the atmosphere in the lungs, the carbon of the blood is thrown off, and the blood, resuming its purity, is again suited to circulate in the body.

What is life? we see it in its effects only; we can in no other way comprehend it. Is the blood alive as the solids are? both are alive; that is to say, they have properties which distinguish them from inanimate matter. The term will only be objectionable to those who have defined life to be the effect of the re-union of the

several parts composing an animal body. The blood possesses properties while circulating in the vessels distinct from those which it shows out of the body; and these do not depend on the agitation and incessant motion, nor on the degree of heat, nor on any similar circumstance, but apparently on some secret influence which the vessels exert over it.

There are produced from the blood a variety of fluids by organs which are called glands, and the formation or separation of these fluids is secretion. But the solid parts of the body ought to be considered as secretions equally with the matter which flows from the ducts of glands. For there is formed and deposited from the blood, during the round of its circulation, bone to support the incumbent weight of the body; muscular fibre, to give it motion; nervous matter giving it sensibility, as well as all the other variety of solids and fluids. The only difference betwixt these solid depositions from the blood and the glandular secretions, is, that the former are still within the influence of the vascular system, and that they are decomposed and re-absorbed, conveyed again into the mass of circulating fluids before they can be finally expelled from the body, while the latter are poured into receptacles, which make their exit by ducts.

The chymists have observed the division of animal bodies into solids and fluids; but the subdivisions of these are very inaccurate. The fluids they have distinguished into three classes: 1st, Recrementitious humours, which go to nourish and support the body: 2dly, The excrementitious fluids, which are carried out of the body by certain emunctuories; and the 3d are of a compound nature, being partly recrementitious and partly excrementitious. We must observe, however, that the fluids enumerated under these heads show it to be a very incorrect arrangement. The *first* division comprehends the fat, the marrow, the matter of internal perspiration, and the osseous juice. The *second* comprehends the fluids of insensible transpiration, the sweat, mucus, cerumen, urine, fæces. And the *last* division comprehends the saliva, the tears, the bile, the pancreatic juice, the gastric and the intestinal juice, the

milk, and the seminal fluid. To attend to their arrangements of the solid parts of animals serves as little useful purpose; for we find substances unlike in structure and discordant in function.

From this short view of the system we understand how the powers are spent in action, and the fluids exhausted by deposition and secretion, and how essential to life the functions of those parts are which act upon and assimilate the food. It is the consideration of those organs which forms the subject of the first section of what remains of the present volume. As in the consideration of these functions the structure of the glandular organs becomes a chief subject of enquiry, it will be natural at present to consider the opinions which have been entertained regarding their structure.

The peculiar nature of that organization by which the several secretions are formed, has eluded absolute proof by experiment or dissection. It is imagined that there are some organs which do little more than separate the parts of the blood like to the exudation by exhaling arteries. But neither in the exhalent arteries nor in the simple organs can I imagine a mere straining of the blood, but rather that the same principle of activity influences all, and that the several varieties of secretion depend upon an action modified by the living property in the secreting part. The fluids in circulation and the vessels containing them reciprocally affect each other: we know that a change on the state of the circulating fluids will alter the nature of the glandular action, and an excitement of the gland will still more powerfully change the nature of the secretion; the active power of the solids appearing to be an agent which controls and directs the chymical affinities.

The term gland is applied to certain solid or firm bodies, with regular and smooth surfaces, which are in great number over the whole body. The functions of many of these bodies are known. They are found to have ducts which convey away a secreted fluid; but in many of them we discover no duct, and can but obscurely guess at their use.

We are struck with the variety of form in the secret-

ing organs. We see a simple surface pouring out its fluids; or a simple canal into which the arteries throw out their secretion. We find again the secreting vessels and their ducts convoluted and massed together, forming such firm glandular bodies as I have just mentioned; of which kind are the solid abdominal viscera. In the glandular viscera there are greater varieties in form than in any of the other parts of the body; but with these variations there is no corresponding change of function. I am of opinion that the forms of the solid abdominal viscera result entirely from their situation. The liver is convex upwards, because the diaphragm is concave; and it is irregularly concave downwards, because in contact with the duodenum, colon, and gall bladder. The same may be said of the spleen, the pancreas, the kidney: their form has reference to place, and has nothing further to do with their functions. The form, in short, results from a system of packing more than any thing else.

When we dissect the glands we do not find them to have much similarity in structure. Thus the substance of the liver, the kidney, the testicle, &c. are quite unlike. There is also a very remarkable difference in the length, size, and form of blood vessels passing into the glands, and of the ducts coming out of them.

In considering the opinions of physiologists or anatomists regarding glandular secretion, and the structure of glands, we find, in the first instance, that the old physicians contented themselves with saying that the glands or viscera possessed a peculiar power to select and separate the fluids from the blood. The next class had recourse to hypothesis; they spoke of the separation of certain parts by means of fermentation*, or by a kind of filtering through the pores or vessels of glands; that these pores allowed only particles of a particular size or figure to pass them.† It was opposed to this hypothesis, that the thinner fluids must have run through the organs destined for the grosser secretions. But when

* Van Helmont. Vieussens, &c.

† Charleton, Descartes, Borelli, Verheyn, &c. &c.

a theory such as this is received, no argument nor proof seems necessary to overthrow it. Resting upon authority alone, it stood until it was overturned by the fashion of new doctrines: one equally puerile was raised upon its overthrow.

We observe, says the founder of this theory *, that wet or oiled paper will only transmit fluid of that kind with which it is previously imbued; it will not transmit the oil when wetted, nor will the water make any impression on the paper when previously oiled. Upon these facts are to be raised a theory of secretion! Betwixt the secreting vessels and the ducts, in the peculiar tissue of which glandular structure consists, there is interposed a fluid of that particular kind which is required to be secreted; and when the blood is driven against this tissue so imbued, no fluid but of a nature resembling that already deposited can be transmitted. By this hypothesis they explained secretion; making it to depend on the attraction and repulsion of the particles of the blood by fluids previously secreted. We may surely leave this class of physiologists accounting for the original deposition of the fluids in the glands without a wish to search with them further into this mystery. Commentators on this theory, by taking into the system the action of the nerves, indicated that they did not altogether foget that the body was alive.†

Another set of physiologists attributed the whole effect of secretion to the velocity of the blood in the glands or secreting vessels ‡; others, to the length and curves of the vessels, and their action upon the fluids. Again, others have been satisfied with the round assertion that the vital action was the essential cause of secretion. This must be acquiesced in, while yet there may remain an enquiry as to the structure and the means employed. While a power exists in an animal body, directing its actions, perhaps both in the solids and fluids, and in the mutual influence which they exert, the form, length,

* Winslow. Helvetius.
† Coner, Tentamen epistolare de Secretione.
‡ Boerhaave, Pitcairn, &c.

and activity of the vessels and ducts give opportunity and time for the operation of that principle upon which the secretion depends.

Let us attend to the observations of anatomists, and to the appearance which the GLANDULAR VISCERA present under the knife.

It is not perfectly clear what the older anatomists meant by the expression Parenchyma; it however saved them the trouble of investigation. They meant flesh, yet not muscular substance, but such as the liver presents. This matter they seem to have conceived to be formed by the blood. Thus Highmore describes the liver to be formed of the blood of the umbilical vein: the opinion originally of Erasistratus.

Previous to the time of Malpighi it is fruitless to trace the opinions of anatomists regarding the structure of glands. He was the first who sought to throw light upon this obscure subject by anatomical investigation, and he made a more rapid progress than has been done by any man since his day. If we take into consideration the difficulties he had to encounter in a new field, and the prejudices of the learned with which he had to combat, his merits will be found greater than even those of Ruysch. The opinions of Malpighi were received by those who, forsaking the authorities of names, saw the importance of the study of anatomy. Ruysch himself gave credit to the opinions of Malpighi in the early part of his life. But Ruysch's more attentive observations being in contradiction to those of Malpighi, his maturer judgment rejected that anatomist's proofs; and with a boldness in which he was never remarkably deficient, he invented a new theory, or at least alleged new facts, and swayed men's opinions with an absolute authority.

MALPIGHI was an Italian, and born near to Bologna. Whilst yet a young man, being sunk under the accumulation of family distress, absorbed in grief, and lost to the consideration of his interest, he received comfort and assistance from his master, who urged him to embrace the medical profession. His progress was rapid. After studying at Padua, he was called to fill one of the chairs in Bologna. He was then solicited by Ferdi-

nand II., Duke of Tuscany, to be professor in the university of Pisa. Here he was associated with liberal men; and now only in his second professorship did he learn to despise the scholastic learning of the time, and betook himself to experiment as the only means by which philosophy could be raised from the oppressive barbarism of the schools. Malpighi and Borelli were associated: they dissected together; they suggested observations to each other; they doubted, and canvassed freely each other's opinions, and were to each other an excitement and encouragement to perseverance and industry. They were supported by government; popular in their teaching, while they collected round them the learned men of the time. This was the origin of the famous Academy del Cimento. Malpighi was, after this, professor in Messene, and died in the Quirinal palace at Rome, of a stroke of the apoplexy*, after having been some time physician to Pope Innocent XII. Malpighi had many enemies, and even some of his colleagues were animated against him with a dishonourable jealousy. Many laughed at his studies and occupations as frivolous and absurd. Something must be allowed for men who had laboured with diligence to become learned; for these, his opponents, had passed their lives in the study of the Arabian writers. With them studies were enforced which held science in subjection; studies which, in place of invigorating, served only to chill and paralyse exertion, and retard ingenious investigation. Even Borelli, but from other motives, opposed and censured some of the dissertations of Malpighi.

Malpighi has been considered as the inventor of this department of anatomy, which the French, curious in distinctions, have called the analytic method. He showed the impropriety of the term Parenchyma, as applied to the substance of glands. He proved that the lungs, for example (which they also called Parenchymatous), were not fleshy, and had no resemblance to the glandular viscera of the abdomen. He taught, that

* Much coagulated blood was found in the ventricles of his brain by Baglivi.

though glands are smooth on their outer surface, they consist of lobules connected by cellular membrane: and, upon a still more minute investigation, that they consist of innumerable little follicles or sacs; that these are interposed betwixt the arteries which convey the fluids and the excretory ducts going out from them; that the arteries, or the vasa efferentia, after ramifying and encircling these bodies, pierce them and secrete the fluids into them. On other occasions he describes these little glandular bodies as appended to the ramifications of the arteries, like fruit hanging by the branches of a tree.

Malpighi threw in his liquid injections; dissected and examined with the microscope; made careful observations and experiments on living animals; and, lastly, attended in a particular manner to the phenomena of disease. By disease, no doubt, parts swell out and are magnified, and become distinct; but it is not a good test of the natural structure.

Boerhaave's plan of Malpighi's doctrine. *aaa* folliculos glandularum simplicissimarum denotat. *bbb* singularia emissaria cuique utriculo *a*, propri atque in communem canalem excretorium *d*, *c*, suos humores demittentia qui tandem per hujus aperturam *e*, emittantur.

Ruysch studied at Leyden, under Van Horne, and at a very early age attached himself to anatomy and botany. At this time he brought himself into notice by a defence of the professors against one Bilsius, who, although he was learned and acute, had attacked them with all the weapons of a charlatan. Returning to his native country, he was raised to the professorship of anatomy and botany in Amsterdam. It was here that Ruysch made those discoveries in anatomy, and that wonderful and sudden progress in practical anatomy, which not only raised him above his contemporaries, but has been the admiration of all since his time. Though new and various methods of preparing the body have been discovered since the time of Ruysch, yet there has been no approach to the elegance with which he displayed the structure of minute parts. It has been

said, that, while others preserved the horrid features of death, Ruysch preserved the human body in the softness and freshness of life, even to the expression of the features. We must, no doubt, ascribe some part of this encomium to the exaggeration naturally arising from the novelty of the thing. But as to his superiority in the manner of displaying the minute vessels of delicate parts, and his methods of preserving the parts in liquors, transparent and soft, and so as to float in their natural folds, there can be no doubt. Neither can the minuteness and success of his injections be denied: we have too many occasions in which we must resort to the catalogue of Ruysch's museum for the true anatomy to doubt his great success, or to question the truth of those encomiums which have been bestowed upon him.

Kings, princes, ambassadors, and great generals, but more than these, all the learned men of the time, crowded to the museum of Ruysch. We must not blame him, if, whilst others were merely speculating about the structure of parts, he, surrounded by so princely a museum, should simply have laid open his cabinets, and bid them satisfy themselves whether or not he was right. Ruysch's preparations went to contradict the opinions of Malpighi. His injections, pushed more minutely, showed those round bodies which are to be seen in some of the glandular viscera (and which Malpighi took to be little bags into which the secreted fluid was poured) to be merely convoluted arteries. Ruysch taught, that the minute arteries, after making these convolutions, terminated in the beginning of excretory ducts; that there was no substance or apparatus interposed, but that the vessels and ducts were continuous. His opinions being formed upon the strength of more minute preparations, and a superior dexterity of anatomical investigation, few anatomists chose to be outdone, or to acknowledge that they could not see what he saw. This I believe to be one reason of the rapid progress of Ruysch's opinion.

It may be further observed, that it was not in the mere fact of there being follicles, in which Malpighi and Ruysch differed; for the latter conceded that there were hollow membranes, but contended that these were

not glands. Their difference of opinion is expressed in the following words of Ruysch: "Adeoque discrepantia inter magnum illum virum et inter me est, quòd ille putat humores delabi in glandulas dictas simplicissimas, — ibi foveri, mutari: Ego puto, quod arteriæ ultimæ succos faciant, et factos ibi deponant."

The opinions of Malpighi and Ruysch have held the schools in perpetual controversy; most anatomists, however, leaning to the authority of Ruysch. There follows these a crowd of French academicians, who, with Boerhaave, may be considered as mere commentators on the original authorities of Malpighi and Ruysch. Some of these argue for secretion by continuous vessels, and contend that the arteries terminate in the excretory ducts; others, that the secretions are made into follicles; and some, as Boerhaave, insist that both are right in their observations, and in the proofs which they have adduced, that secretion is in part performed by continuous vessels, partly by a more intricate glandular apparatus.

I wish to speak with respect of Bichat, yet I cannot help saying that it is edifying in a way which he did not intend, to find him thus expressing himself. Authors, he says, have occupied themselves a great deal about the intimate structure of glands. Malpighi admits that they are small bodies of a peculiar nature, and Ruysch has established that they are entirely vascular. Let us neglect these idle questions, where neither the eye nor experiment can be our guide; let us begin to study anatomy where the structure of organs comes under the senses. The rigorous advance of science in this age does not yield to these frivolous hypotheses; and so forth. Thus Bichat does not retrace the steps of the mechanical philosophy, nor enter into the science of hydraulics, nor attach himself to the newer school of chemical physiologists, but gives origin to a new school. He boils the liver and the kidney, &c. he dries them, boils them again; observes with all possible minuteness and gravity what floats in scum, what remains behind, what gets soft, what hardens by boiling; he smells and tastes; or he roasts the glands with the same ceremony, and still

imagines the while he is deeply philosophical. But all methods bring us nearly to the same conclusion, and certainly explain nothing at all of the nature of secretion.

Of the secretions discharged from the glands it may be sufficient to say, that many of them are destined to be useful to the further operations of the economy; that they are all liable to be absorbed upon any obstruction to their evacuation; and that, as far as experiments on brutes go, all the animal secretions may be even injected into the circulating fluids without greatly disordering the system.*

The blood carried into the glands has nothing peculiar in its appearance and sensible qualities; the idea once entertained, that the blood issuing from the heart immediately commences a separation of its parts for the several secretions, is quite unsustained; and if it deserves a serious refutation, we have it in the varieties to be observed in the distribution of the arteries to the glands; for a different origin of a secreting artery would in that supposition change the secretion.†

In some of the glands the arteries and veins have a peculiar appearance; they are convoluted, and reflected so curiously, as to have given rise to the idea of their preparing the blood for the secretion: thus in the spermatic cord the vessels have been called the *vasa preparantia*. But this convolution of vessels is for another purpose.

Nothing peculiar has been observed in the distribution of nerves to the glands. They are comparatively small. They have been cut, and still the secretion has gone on. As, however, most of the higher and distinguishing properties of life reside in the nervous system, so it is reasonable to suppose that not only the various

* Haller, by experiments, proved that several kinds of foreign matter may be conveyed into the circulating blood; and Bichat has made the experiment of injecting all the animal secretions into the veins of brutes.

† Bichat has also taken the trouble of examining the blood of the carotid artery, and of the spermatic artery, without being able to observe any difference.

sympathies and sensibilities which the glands possess are derived from the nerves, but also that the secretions which they separate from the general mass of blood are owing to an influence of life residing in their nerves. An imperfect knowledge of anatomy, and especially of the connections and relations of the nervous system, gives rise to very useless experiments. Is it not strange that experimenters should think that they cut off nervous energy by cutting through the nerve? This is still proceeding upon an old-fashioned opinion, that the brain secretes the nervous spirits, and the nerves dispense them!

Let us be satisfied with knowing a little. The *life* residing in the gland is an agent controlling the affinities. The liver or the kidney secrete bile and urine, not because they have a certain form, or certain length of vessels, but because the affinities of the constituent parts of the blood are controlled by the living principle in the gland.

As the forms of the parts which throw out secretions have a great variety, it may be useful in this introductory view to point out these varieties, and their appropriate names.* In the first place, although in general language the term gland implies a secreting body, yet this does not follow from the definition of that word. According to Hippocrates, it is a tumid round body, soft, smooth, and shining. Many such bodies, and which we call glands, have no excretory ducts, and do not secrete a fluid; while most secreting parts admit of no such definition. When, again, we admit the definition of authors who have taught their peculiar opinions regarding their structure, we have a still less admissible description. Thus Malpighi defined a simple gland to be "Membrana cava cum emissario;" and Ruysch says, "Glandulæ, non nullæ componuntur ex sola membrana cava cum emissario sed præcipue ex vasis."

These definitions of glands being optional and uncertain, it is necessary to use names appropriated to the

* The terms acini, cotulæ, cryptæ folliculi, glandulæ, lacunæ, loculi, utriculi, have been almost promiscuously used; being so many names for bundles, bags, bottles, holes, and partitions.

several varieties of form in secreting parts. Indeed, the term gland is useless as conveying any knowledge of the structure of which the viscera are composed.

We must observe, however, that there is a division of glands still in use into *conglobate* and *conglomerate*. The first implies a gland simple in its form, the latter a gland having the appearance of an assemblage of several glands.* There is no gland that has not more or less the appearance which is described by conglomerated; that is, consisting of several parts, united by cellular membrane; and the distinction is attended with no advantage.

Acini (the stones of grapes, literally,) form the last subdivision which we observe in the viscera, as in the liver; they are round bodies, not regularly invested with membranes, and which can be teased out into parcels of minute vessels.†

Cryptæ (implies cells or cavities) are numerous in the body. We have an example of them in the great intestines.‡ Rusych, denying the definition of Malpighi, says, Crypta signifies a soft body, consisting of vessels not completely surrounded with a membrane, and resolvable by boiling or maceration.§

Folliculi are little bags appended to the extremity of the ducts, into which the secretion is made, and from which it is evacuated by the ducts.

Lacunæ are little sacs opening largely into the passages (as in the urethra), and into which mucus is secreted, lodging there for a time, to be discharged when occasion requires the lubrication of the passage.

* As the salivary glands and the pancreas. Farther, the lymphatic glands are generally called conglobate glands, being smooth, and apparently simple in their structure; but these, when injected, take exactly the appearance which should naturally be described by the term conglomerate, consisting of many little cavities. These lymphatic glands, belonging to a distinct system, require no farther particular definition to distinguish them.

† See farther of the acini of the liver for example.

‡ Ruysch ad Virum Clar. H. Boerhaave, p. 53.

§ "Cryptarum vascula possum docere, sed sunt tam subtilia, ut reptatus non possit distingui: tantum circum affusa rubedo per repletionem videtur." (Ruysch ad Her. Boerhaave, p. 77.)

The best example of this structure is at the root of the tongue, when the glandular textures have been swollen by inflammation.

Finally, we have to recollect that every part of the body secretes; that every surface is a secreting surface; that even that surface which is produced by an incision no sooner ceases to bleed than a secretion begins; and that an ulcer in the skin or flesh becomes by habit similar to those organs, the peculiar function of which is to secrete some matter useful in the system. This fact corrects the notions which we should otherwise be apt to receive of the action of secretion requiring a complicated apparatus, from contemplating the more complicated glandular organs.

OF THE ABDOMEN IN GENERAL, AND OF THE PERITONÆUM.

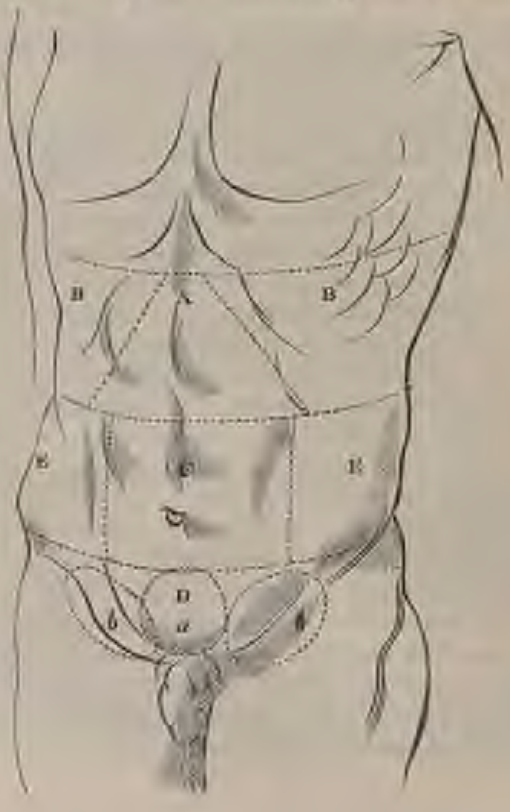
The abdomen is that division of the body which is betwixt the thorax and pelvis. It is bounded above by the arch of the diaphragm; behind, by the spine; on the sides and fore part by the abdominal muscles; and below, the abdominal viscera are supported by the alæ ilii and the ossa pubis. The abdomen contains the viscera, which are for the purpose of receiving and assimilating the food, and the organs immediately connected with them. Nature, by the classification of the parts in the great cavities, declares a connection of these parts in function, which is never to be lost sight of.

We speak of the *cavity* of the abdomen; but it is an inaccuracy of language; for there is really no cavity. The parietes of the abdomen, viz. the abdominal muscles and peritonæum, closely embrace the contained viscera. To understand what is meant by the cavity of the abdomen, to understand the connection of the several viscera, and the manner in which they lie contiguous, while they adhere at certain points only, we must attend to the peritonæum. But, in the first place, let us notice the outward divisions of the belly.

OF THE REGIONS OF THE BELLY.

To give greater accuracy to the description of the seat of the viscera, or, perhaps, rather more strictly, to connect the knowledge of the internal parts with the outward marks of the belly, it has been long customary to mark certain arbitrary divisions on its surface, which are called regions.

The EPIGASTRIC REGION (A) is the upper part of the belly, under the point of the sternum, and in the angle made by the cartilages of the ribs. Upon the sides covered by the cartilages of the ribs are the HYPOCHONDRIAC REGIONS, or the right and left hypochondrium (B B). These three regions make the upper division of the abdomen, in which are seated the stomach, liver, spleen, pancreas, duodenum, and part of the arch of the colon. The space surrounding the umbilicus, be-



twixt the epigastrium and a line drawn from the crest of one os ilii to the other, is the UMBILICAL REGION (C), and here principally are the small intestines. The HYPOGASTRIC REGION is of course the lowest part of the belly, consisting of the angle betwixt the umbilical region, the spines of the ossa ilii and the pubis (D). The two lateral spaces betwixt the false ribs and the spine of the os ilii, and behind the line perpendicular to the spine of the ilium, are the ILIAC REGIONS (E E), and behind those the LUMBAR REGIONS, or the LOINS: here the kidneys are seated and part of the colon. The hypogastric is divided into three, the pubic in the middle (*a*), and an inguinal on each side. (*b b*)

OF THE PERITONÆUM.

The peritonæum, like all the other membranes of the body, consists of an expansion of dense cellular membrane; yet it is what is called a proper or true membrane; being a white, firm, thin contexture of cellular substance, in which no fibre or striated appearance is to be observed.* By its outer surface it adheres to the adipose membrane, on the inside of the abdominal muscles, and to the surface of the several viscera; its inner surface is smooth, and forms no adhesion while the parts are sound and healthy; its outer surface is looser in its texture, and by the splitting of

* The meaning of some anatomists saying that the peritonæum is a double membrane will be seen below.

its lamina it may be traced into the common cellular membrane.

The cellular membrane on the outside of the peritonæum is in some places short, firm, and dense; as on the liver, the spleen, the uterus, and the intestines: but it is longer, lax, and fatty, where it attaches the peritonæum to the muscles and tendons of the abdomen.

The peritonæum has no termination; or it is a sac; yet so curiously is it involved with the viscera, that though we say the viscera are contained in the abdomen, yet, accurately speaking, they are without the peritonæum, and consequently do not lie in the abdominal cavity.*

Let us follow it in its inflections, and suppose that we have opened the sac (that is the cavity of the belly), we find it first expanded on the lower surface of the diaphragm; and at some of the interstices or perforations of that muscle or its tendon it comes in contact with the pleura, and adheres to it by cellular substance. From the diaphragm the peritonæum is reflected off to the liver (A), forming the ligaments of that viscus, and, expanded over its surface, it forms its outer membrane. From the diaphragm it is also sent off upon the œsophagus and stomach, and prolonged to the spleen on the left side (as it is to the liver on the right) so as to form the ligaments of the spleen.

The aorta, the great vena cava, the thoracic duct, and the kidneys, are behind the peritonæum; that membrane being stretched before them. But the intestines are also in the same respect behind this general investing membrane; for it is merely reflected from the spine and psoas muscles, and from the great vessels running down upon the spine, so as to involve the intestines and form their outer coat. (B) As it stretches towards the intestines, it involves the vessels of the intestines in the duplicature, and forms the mesentery. (C)

The peritonæum also lines the abdominal muscles D; it is reflected from the diaphragm upon the surface of

* The figure represents an ideal section of the abdomen; the edge of the peritonæum is represented by the dotted line.

the transversalis and rectus abdominis muscles. Here it is united to them by a loose adipose membrane, and from the abdominal muscles it is continued upon the inside of the pubes. From the pubes it ascends upon the bladder of urine E; descends again behind the bladder; and there, making another reflection to mount over the rectum F, and form the meso-rectum, it leaves betwixt the rectum and bladder a particular sacculus; or if the uterus intervene, the peritonæum having descended on the back part of the fundus of the bladder, it is again in a similar manner reflected over the uterus G. The kidney H is behind the peritonæum; but so are the other viscera. The only difference in their relation to this membrane being, that they hang further into its embrace.

From this detailed description we see that the peritonæum has no termination; that it is continued from the surface of the diaphragm to that of the abdominal muscles; from that over the bladder and rectum; from the rectum in the whole length of the intestinal canal; and from the intestinal canal up upon the diaphragm. We see then what is meant when it is said that it is a shut sac; we understand by the cavity of the peritonæum merely the inside of this sac; and that when distended with fluid, the fluid is contained betwixt the peritonæum lining the abdominal muscles, and that part of it which invests or forms the outer membrane or coat of the intestines. This fluid, whether collected there by disease or thrown in by experiment, has no natural outlet, nor does it transude in the living body.*

* We not unfrequently find an accurate general description in authors, but some incorrectness in the subordinate detail, which throws back the ideas of the reader into confusion. Such is the enumeration of the holes or perforations of the peritonæum, "pour donner passage à l'œsophage, à la veine-cave," &c. See Anatom. Chirurg. par M. Palfin. We see that there are no such perforations, that the œsophagus never enters into the cavity of the peritonæum, nor does the rectum pass out from its cavity. This was indeed explained by Fernelius, in opposition to Galen. See a description of the inflections of the peritonæum, by Bartholin. — Specimen Historiæ Anatomicæ Analect. Ob. I.

BLOOD-VESSELS OF THE PERITONÆUM.

As the peritonæum is a membrane of great extent, and investing a variety of parts, its vessels come from many sources. It receives arteries and veins from the mammary vessels; from the phrenic and epigastric vessels; from the lumbar arteries and veins; and from the ilio-lumbales, circumflexæ ilii, renal, and spermatic arteries. It receives nerves from the intercostal, lumbar, and diaphragmatic nerves.

It would appear that disease has given rise to the opinion that the peritonæum has in it many little glands. This is controverted decisively by Morgagni: there are no glandular bodies in the peritonæum.

OF THE USE OF THE PERITONÆUM.

The peritonæum serves as a dense and outer coat to the abdominal viscera; conveys the vessels to them, as in the example of the mesentery; and, having its inner surface smooth and lubricated by a watery secretion, it allows the parts to lie in contact (they being strongly compressed by the surrounding abdominal muscles and diaphragm), and at the same time allows in the intestinal canal a capacity of motion without friction.

There is no internal surface or cavity, as it is called, of the living body, which is not moistened by an exudation from the vessels of the surface. Thus it is with the peritonæum. An exhalation from the extreme arteries bedews its surface, and is again taken up by absorbent vessels; so that it does not accumulate in health, nay, even fluids poured into the abdominal cavity will be taken up by the absorbents.* When the abdomen is opened in animals alive, or recently killed, as in the

* See Nuck Sialograph. c. ii. p. 27.

"Qua copia in statu secundum naturam secernatur dictu difficile est: ad uncias certe collecta aquula in sani hominis abdomine reperitur. (Kaawn, 543.) In homine, cui sponte abdomen sub umbilico ruptum erat ad quinque et sex libras de die effluebat, ut denique 800 libr. effluxerent." (Journ. de Med. 1757. M. Aug.) This, however, proves nothing of the nature or quantity of the secretion; this has probably been an inflammation and abscess of the peritonæum, which we have seen pours out such a quantity of fluid, thin and serous, as quickly to drop through the bedclothes upon the floor.

shambles, a vapour is seen to exhale from the peritonæum, having a peculiar animal odour. Yet we ought not to say that this vapour is collected in the dead body: for before the opening of the peritonæum, or the death of the animal, it is not in a state of vapour, but is condensed into a watery exudation. *

We see the *capacity* of secretion of the peritonæum very well in hernia, where the peritoneal surface will in a very short time pour out a great quantity of serum.

One great use of the peritonæum is to retain the viscera in their place, says Haller; for when it is wounded, they escape, and sometimes with a sudden impetus, which makes it difficult to reduce or retain them.† But this is not from the want of the embracing of the peritonæum, but from the tendons or muscles which support the peritonæum being cut; for when there is a deficiency in the support given by the abdominal muscles, or their expanded tendons, the peritonæum does not prevent the viscera from being protruded, but easily yields to their forcible protrusion, and forms a sac involving this hernia.

Nor do the processes of the peritonæum, which have received the name of ligaments, nor the mesentery, nor mesocolon, sufficiently resist the prolapsus of the viscera when they have escaped from the pressure of the surrounding muscles. Sufficient example of this we have in hernia of the intestines, in which the mesentery is greatly elongated, or in the displacement of the stomach, or in the prolapsus and procidentia uteri.

The peritonæum which forms the sac of hernia retains little elasticity, and does not shrink into the belly when freed from the outer adhesions; but the general peritonæum will allow great distention, as in ascites, and quickly contract to its former dimensions on the evacuation of the fluid; and so that part of the membrane which invests the stomach and intestines, the bladder of urine and gall bladder, has considerable elasticity, since

* This vapour I have seen arising from the intestines of the human body during the operation for hernia; and also when the omentum and intestines have escaped in consequence of a wound of the belly.

† Element. Physiol. tom. ii. p. 380.

it suffers these parts to be distended, and again returns to its former dimensions.

The consideration of the insufficiency of the peritonæum to retain the viscera leads us to attend to a circumstance of the greatest importance connected with the viscera of the belly. The abdomen is every where (except towards the spine) surrounded by muscles. Above we see the diaphragm; before, and at the sides, the abdominal muscles; and even below, the parts in the pelvis are surrounded and compressed by the levator ani, in such a manner that the whole of the viscera suffer a continual pressure. This pressure upon the viscera appears to be uniform and constant, notwithstanding the alternate action of the abdominal muscles and diaphragm as muscles of respiration: but it must be occasionally very violent, as during exertions; in pulling, for example, or in straining, as a sailor must do in working of the great guns, or when pulling at the oar, or when balancing himself upon his belly over the yard-arm. And indeed by such violent and general compression of the viscera of the belly, ruptures are sometimes produced, of the worst kind, and followed by an immediate train of urgent symptoms.

The viscera having, in general, delicate outer coats, and no ligaments capable of supporting them, and being very vascular, require the aid of this pressure of the surrounding muscles; and the great venous trunks, which take their course through the abdomen, are in a particular manner indebted for their security to the pressure of the abdominal parietes. We must recollect also the bad consequences which result from the sudden relaxation of the abdomen; as in women after delivery, or in consequence of withdrawing the water of ascites without due compression of the belly; languor, faintness, and even death, are sometimes produced, apparently by the balance of the vascular system being destroyed.

Some good authors, in former times, have described the peritonæum as a double membrane.* This was no farther a mistake than as they considered the cellular

* See Anat. Chirurg. par M. Palfin, tom. ii. p. 35. and note *a*.

membrane, which lies without the peritonæum, as a part of it. It is necessary to recollect this, in order to understand the meaning of their calling the sheath of the cellular membrane, which accompanies the vessels passing out from the abdomen, productions of the peritonæum. The vaginal productions of the peritonæum are the sheaths of the common cellular substance which accompany the aorta and œsophagus into the posterior mediastinum; or which give a bed to the spermatic vessels; or, passing under Poupart's ligament, accompany the vessels of the thigh. They are improperly termed productions of the peritonæum.

The proper productions, or prolongations of the peritonæum are of a very different kind; they are the ligaments and plicæ, the mesentery, mesocolon, and omenta.

OF THE LIGAMENTS AND FOLDS FORMED BY THE PERITONÆUM.

There are certain ligaments and plicæ formed by the peritonæum, which, to enumerate, will carry us again over all the extent of its surface. When this membrane is reflected off to the œsophagus from the diaphragm, it forms, 1. the *ligamentum dextrum ventriculi;* and 2. the *vinculum œsophagi*. In the same manner is formed, 3. the *ligamentum inter œsophagum et lienem*, which we may trace into the omentum majus, presently to be described. From the spleen we may trace the membrane into, 4. the *plica renalis* and *capsularis;* 5. another *plica* or duplicature may be traced from the kidney to the colon, and on the right side, 6. the *plica duodeno-renalis*, viz. from the kidney to the duodenum. When we turn up the liver, we are led to observe the five ligaments to that viscus, to be described in their proper place, and from the liver stretching to the kidney we find the 7. *ligamentum hepatico-renale* still tracing the convolutions of the intestines, and following the *mesentery* or ligament of the small intestines into the *mesocolon*, or ligament of the great intestines, and the *mesorectum* or process of the peritonæum to the rectum; we there see the 8. *plica*

semilunaris, which is before the rectum, and behind the bladder of urine.

The young anatomist ought to trace all these processes of the peritonæum, both to comprehend the great extent of this membrane, and more especially to learn the relations of the viscera to each other.

OF THE OMENTA.

The omenta are fatty membranes which hang over the face of the bowels. They are considered as secondary processes of the peritonæum, because they are not formed by the peritonæum reflected off from the spine upon the intestines, as the mesentery is, — it being a primary process; but they are reflected from the peritoneal surface of the stomach and intestines. Anatomists distinguish the *omentum majus*, or colico-gastricum: the *omentum minus*, or hepatico-gastricum; *omentum colicum*, dextrum et sinistrum; and, lastly, the *appendices epiploicæ*.

The OMENTUM, or EPIPLÖON, meaning thereby the great omentum, is a floating membrane of extreme delicacy, expanded over the surface of the small intestines, and attached to the great arch of the stomach and intestinum colon. Although this membrane be of extreme delicacy and transparency in the young subject*, yet it is much loaded with fat, and appears transparent in the interstices only; and in advanced age it loses much of its delicacy, and acquires a degree of consolidation or firmness, and is often irregularly collected into masses, or adheres preternaturally to some of the viscera.

The omentum majus hangs suspended from the cellular connection betwixt the arch of the stomach and the great transverse arch of the colon; or rather it forms

* "Preterea tenerrimas esse ut nulla membranarum humanarum, retina oculi excepta, æque sit tenera." — Haller, vol. vi. lib. 20. § 1. par. 12.

While its delicacy is remarkable in the young subject, the retiform vessels (vid. Ruysch. Ther. II. Q. V. Spigel. LVIII, &c.) have the fat accumulated in their tract, as if it were thrown up by them to a side; but often, the fat increasing, obscures the vessels.

that connection betwixt the stomach and colon. It consists of two membranes, or is as a sac collapsed and hanging from the stomach and colon *, one of the sides being the peritonæum reflected off from the œsophagus and along all the great arch of the stomach, and the other that which comes from the arch of the colon. And further, each of these laminæ may be supposed to consist of two laminæ; for example, where the omentum is formed by the meeting of the peritonæum from the lower and upper surfaces of the stomach; these two uniting form the upper lamina; and where the lower layer of the omentum comes off from the colon, it is also formed by the peritonæum reflected in the same manner from both sides of that intestine; so, with some truth, the omentum is supposed to consist of four laminæ of membranes of extreme tenuity: but these four layers cannot be demonstrated. The great omentum extends from the bosom of the spleen transversely, until it terminates on the right side of the arch of the colon, where the omentum colicum begins.

The great omentum varies considerably in extent.—In a child it is short; in the adult further extended over the viscera: sometimes it reaches only to the umbilicus; sometimes it is allowed to extend its margin into the pelvis, so that in old people it is very apt to form a part of the contents of hernia; often it is wasted and shrunk; sometimes collected into masses, leaving the surface of the intestines.

My reader must now find his way into the *marsupium*, or purse of the omentum, viz. the *porta omenti*, the celebrated foramen of Winslow. It will be found to be a slit betwixt the ligamentum hepatico-colicum and hepatico-duodenalis, being under the biliary vessels and vena portæ. Upon blowing into this opening, in a young subject, three omenta are distended, viz. the *omentum hepatico-gastricum*, the *colico-gastricum*, and the *colicum*.

This opening serves as a communication betwixt the cavities of the omentum and the general peritonæal ca-

* Marsupium the common term — See Winslow, IV. p. 352.

vity; but I am inclined to think it is very frequently destroyed by adhesions.* As this opening points towards the right side, Dr. Monro thinks it a sufficient reason for introducing the trochar on the right side in the operation of tapping for ascites (contrary to the usual caution of avoiding the liver, which is so often diseased in this case); by operating on the left side he thinks the water will not be allowed to flow from the sac of the omentum. It appears to me that it will flow equally well from whatever point of the belly the water is drawn.

OF THE OMENTUM MINUS, OR HEPATICO GASTRICUM.

This is a membrane of the nature of that last mentioned, but in general less loaded with fat. It is extended from the liver to the lesser arch of the stomach. It passes off from the lower surface of the liver at the transverse fossa; from the fossa ductus venosi; invests the lobulus Spigellii; involves the branches of the cœliac artery; and is extended to the lesser curvature of the stomach and the upper part of the duodenum. †

OMENTUM COLICUM.

This is a continuation of the great omentum upon the right side of the great arch of the colon, where it rises from the caput coli; but it seldom extends its origin from the colon the length of the caput coli. It is inflated with the great omentum.

APPENDICES EPIPLOICÆ, OR OMENTULA INTESTINI CRASSI.

These are little fatty and membranous processes, which hang pendulous from the surface of the colon: they are of the same texture and use with the greater omentum and right colic omentum.

* Winslow, Duverney, and Haller.

† "Macilentius est, et vasa habet minora." (Winslow. Haller.) Indeed, it seems rather to answer the general purpose of a cellular membrane conveying vessels, than the purposes of the omentum majus.

We have mentioned that the omenta are double reflections from the peritonæum, and consequently they may be inflated so as to demonstrate them to be perfect sacs. To do this it is not required to puncture any part of them; for, by the natural opening just described, the whole may be inflated in a young subject, and in a healthy state of the viscera.

There is a considerable variety in the form of the omentum of animals *; but still they seem to show the same provision of covering the intestines, filling up the inequalities which arise from the rounded forms of the viscera, and still further lubricating and giving mobility to the intestines. † The surface of the omentum, however, seems merely to furnish a fluid exudation like the general surface of the peritonæum; and the idea which has been entertained of the oil or fat exuding is not correct. ‡

The use assigned to the omentum, of being subservient to the function of the liver, is deservedly neglected. §

OF THE VISCERA OF THE ABDOMEN.

Having understood the nature of the general investing membrane of the abdomen, and what is meant by its cavity and its processes, we take a general survey of the

* Haller Element. Physiol. tom. vi. lib. xx. § 2 and 3.

† We must not suppose that because a madman stabs himself in the belly, and there is afterwards found adhesion of the intestines to the wounds, the omentum has not done its office (see Boerhaavii Prelectiones, vol. i. § 45): no more can we give credit to the tale told by Galen (De Usu Partium, l. iv. c. 9.) of the gladiator who lost part of the omentum, and ever after had a coldness in his guts! At least, we cut out a great part of the omentum from a man without any such sensation being the consequence now-a-days.

‡ "Et dum halitu pingui et ipsa obungit et peritonæum." Haller loc. cit. Boerhaave, &c. Morgagni Adversar. III. Animad VI.

§ Viz. by supplying a gross oily matter to the venæ portæ.

economy of the viscera, before entering upon the minute structure of the parts individually.

The contents of the abdomen are thus enumerated in elementary works on anatomy.

1. The MEMBRANOUS VISCERA, viz. the stomach, the small and great intestines, the gall-bladder, mesentery, the mesocolon, and ligamentous processes, and the omenta.

2. The SOLID VISCERA, viz. the liver, spleen, pancreas, the kidneys, and renal capsules, the mesenteric glands. But a natural order in the arrangement of these viscera is to be preferred.

The organs destined to receive the food, and to perform the first of those changes upon it, which fit it (after a due succession of actions) for becoming a component part of the living body, are the stomach and intestines primarily; the glandular viscera, the liver, pancreas, and the spleen, are subservient or secondary organs. I have been accustomed in my lectures to divide these parts into those which have action and motion, and those which are quiescent, or possessed of no power of contraction. Thus the stomach, intestines, gall-bladder, and bladder of urine (though this belongs to the pelvis) have muscular coats, and the power of contracting their cavities: while the liver, spleen, pancreas, and kidneys, have no muscularity.

This division of the viscera may lead to important distinctions in pathology. During inflammation, it is observed, that though the parts possessing a power of contraction may sometimes lie inactive without pain, yet in those parts when roused to action there is excruciating pain. On the other hand, it often happens that the glandular and solid viscera are the seat of long-continued disease, which is attended only with a dull or low degree of pain; and the anatomist is often struck upon examining the body after death with the wide ravages of a disease which gave no sign during life.

We divide the intestinal canal into three parts; the stomach, the small intestines, the great intestines. The small intestines are subdivided into the duodenum, jejunum, and ileon. The great intestines are subdivided into the cæcum, colon, and rectum.

The stomach is the seat of the digestive process: in the duodenum the food receives the addition of the secretions from the liver and pancreas, and is still further changed; in the long tract of the jejunum and ileon the nutritious part is absorbed; and in the great intestines the foul sediment becoming fæces, is carried slowly forward, suffers a further absorption of fluid, lodges in the lower part of the colon, and then in the rectum or last division of the canal.

From this view it is apparent that each division of the intestinal canal is marked by some peculiarity in its use or function; we must carefully examine their minute structure as individual parts; at the same time that we do not allow ourselves to forget the connection, the relation of the organs, and their economy as a whole. With this intention, following the course of the food, we treat first of the œsophagus.

OF THE ŒSOPHAGUS.

The œsophagus or gullet is a cylindrical muscular tube, which conveys the food to the stomach. It is continued from the pharynx down behind the larynx and trachea and close before the spine, and, continuing its course in the back part of the thorax, it perforates the diaphragm, and expands into the upper orifice of the stomach.

Although with many authors I call it a cylindrical tube, and it may take this form when dissected from the body and inflated, yet during life it lies collapsed with its inner membrane in close contact. It is dilated only by the passing down of the food or drink, and then partially only, since the matter taken into the stomach does not flow as through an inactive tube, but the morsel is transmitted by a succession of contractions of its fleshy coat.

The upper part of this tube is called the pharynx. It may be described as being expanded like a funnel; it is attached to the occipital bone, pterygoid processes of the sphenoid bone, and jaw-bones; and further down it is kept expanded upon the horns or processes of the

os hyoides. The lower part of this funnel may be said to terminate in the œsophagus; for although the tube be continuous, and there be no absolute difference in the texture of the pharynx and the œsophagus, yet the tube is attached in such a manner to the cricoid cartilage as sufficiently to mark the termination of the pharynx and the commencement of the œsophagus. It is here that the tube is narrowest and least dilatable, owing to its connection with the cricoid cartilage. This is a point of the anatomy which must be particularly studied by the surgeon, for here he will meet with difficulty in attempting the introduction of instruments, and here is the seat of stricture. This bag is very fleshy, being surrounded with muscular fibres, which take their origin from the neighbouring fixed points; as the styloid process, the horns of the os hyoides, the thyroid cartilage; by which it is enabled to grasp and contract upon the morsel when it has been thrust by the tongue behind the isthmus faucium. This strong tissue of muscular fibres which surrounds the pharynx is continued down upon the œsophagus in the form of a sheath, which has been called tunica vaginalis.

I believe we can with propriety enumerate no more than two proper coats of the œsophagus, its muscular and internal coat: for that which is sometimes considered as the outer coat, is only the adventitious cellular membrane; and the nervous coat is merely cellular tissueconnecting the muscular and inner coats.

The MUSCULAR COAT of the œsophagus greatly surpasses in strength and in the coarseness of its fibres any part of the whole tract of the intestinal canal. There may be very distinctly observed in it two layers of fibres; an external one consisting of strong longitudinal fibres, and an internal one of circular fibres. These laminæ of fibres are more easily separated from each other than those in any other part of the canal.* But an idea

* It appears that the œsophagus can be ruptured in two ways; across, by the tearing of the longitudinal fibres; and longitudinally, by the separation of the longitudinal fibres. This, though a rare accident, takes place in violent vomiting or straining to vomit; and,

is entertained that the one or other set of fibres, the circular and internal ones, are for contracting the tube, and the outer ones for elongating and relaxing it. I believe, on the other hand, that they contract together, conducing to one end, deglutition.*

What is called the TUNICA NERVEA is the cellular connection betwixt the muscular and inner coat; it is very lax, insomuch that the muscular coat and the inner coat are like two distinct tubes, the one contained within the other, and but slightly attached. This appearance is presented particularly when the œsophagus is cut across.

The INNER COAT of the œsophagus is soft and glandular; villi are described as being distinguishable on its surface, and it is invested with a very delicate cuticle which dulls the acute sensibility, and prevents pain in swallowing. It in every respect resembles the lining membrane of the mouth. The power, however, which the œsophagus seems to possess of resisting heat depends not on the insensibility bestowed by the cuticle, but is owing to the rapid descent of the hot solids or liquids swallowed; for when they happen to be detained in the gullet they produce a very intolerable pain. This inner coat has an exhaling surface, like the rest of the body, with particular glands to secrete and pour out that mucus which lubricates the passage for the food. These glands suffer ulceration and schirrous hardening, and are a terrible cause of obstruction to swallowing. The inner coat is capable of a great degree of distention; but it is not very elastic, or, at least, contraction of the muscular coat throws it into longitudinal folds or plicæ.

In the neck the œsophagus lies betwixt the cervical vertebræ and the trachea, but is at the same time in a

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in the first instance, the tearing across of the œsophagus seems to be the effect of the action of the diaphragm on the œsophagus. By this accident the fluids of the stomach are poured into the cavity of the thorax.

* See farther of the muscular coat of the intestines. "It was at one time supposed that the muscular fibres of the œsophagus had a spiral direction." See Verheyen, and Morgagni Adversar. iii.

small degree towards the left side. At the bottom of the neck it perforates the membranous fascia, and enters the thorax. Here the surgeon should take good heed of the relation of the tube to the fascia, for I have seen a stricture imagined to be present from an instrument resting on this membranous connection. When the œsophagus has entered the thorax it descends, retiring a little backwards at the same time, and passing behind the bifurcation of the trachea and the arch of the aorta; when it descends farther upon the dorsal vertebræ, it lies rather to the left side; escaped from the aorta, it lies on the right side of it, and as it passes further down it gets more and more before the aorta. This is sufficiently apparent when we attend to the relation of the perforations in the diaphragm for transmitting the aorta and the œsophagus.

Behind the œsophagus, in the thorax, there are one or two lymphatic glands, which were understood by Vesalius to belong to the œsophagus. What deceived him is an appearance to be observed in these glands. The lymphatics, or the small branches of veins, are generally filled with a black matter, which, extending to the coats of the œsophagus, resemble very much the ducts of the glands going to open into the œsophagus. These glands in the posterior mediastinum are sometimes diseased, and enlarged so as to compress the œsophagus, and to cause so permanent an obstruction of deglutition as to occasion death.

The inner coat of the œsophagus shows so very different a texture from that of the stomach, and this difference is marked by so very abrupt a line; the delicate cuticular lining terminates so abruptly, the one for transmission merely, the other for the lodgement of the food and for digestion, as sufficiently to indicate the different offices performed by the œsophagus and stomach.

OF THE STOMACH.

The stomach is that capacious membranous bag into which the œsophagus delivers the food, and in which the process of digestion is performed. The food of

animals is of various kinds, and the form and structure of the stomach varies according to the nature of the food. Animal food affords a rich aliment in a state nearly prepared for supplying the deficiencies of the living system. In such animals as live on flesh the stomach is simple in its form, and possesses little muscular property. On the contrary, vegetable food has a smaller proportion of nutritious matter in it, requiring for its separation a more complicated and tedious process of maceration, trituration, and digestion. Therefore in brutes living on vegetable matters we observe a more intricate system of reservoirs, for separating and preparing the food for the operation of the digesting stomach or true stomach. The human stomach is simple compared with the stomach of the herbivorous animals, but more curiously guarded to retain and fully to operate upon the food than the carnivorous stomach.

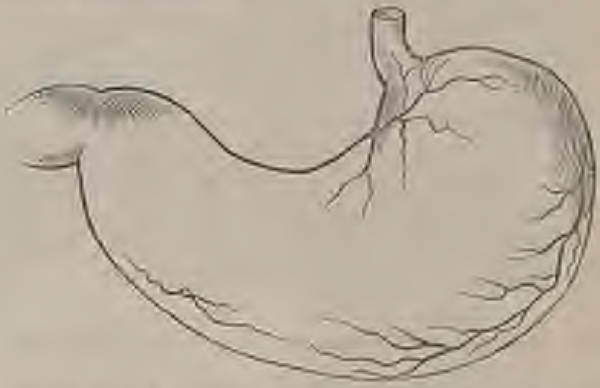
Since I am entering on this subject, I may add, that the length and intricacies of the intestines hold always a relation to the form of the stomach. If the food of an animal be of difficult digestion, and offer little nutriment, as it requires a complicated stomach to prepare its food, so will it require to be carried through intestines long and intricate, that opportunity may be given for the whole nutritious matter to be absorbed out of the mass, and turned to use. But if, on the contrary, the food be rich in nutritious matter, the intestines will be shorter, more direct, and have less of that apparatus intended to delay the course of the contents.

SEAT, FORM, DISPLACEMENT OF THE STOMACH.

The stomach lies under the margin of the ribs of the left side, and chiefly in the left hypochondrium, but stretches into the epigastrium. Its greater extremity is on the left side, in contact with the diaphragm; towards the right, the shelving edge of the left lobe of the liver is betwixt it and the diaphragm. On the lower part it is separated, by the mesocolon and arch of the colon, from the small intestines; and to the greater extremity the spleen is attached by vessels and by the loose inter-

texture of the omentum. The stomach may be said to be a conical sac; the extremities of which being made to approach each other, gives it the curve of a hunter's horn, and this is the reason that the anatomist describes these parts; the SUPERIOR OR CARDIAC orifice into which the œsophagus expands; the LOWER OR PYLORIC orifice, which leads into the duodenum; the LESSER CURVATURE and GREATER CURVATURE of the stomach; and the great bag or extremity towards the left where the spleen is attached, and the inferior or lesser extremity extending to the right side, and in a direction obliquely downwards.

The lesser curvature of the stomach extends from betwixt the two orifices; includes in its embrace the spine, the aorta, and the small central lobe of the liver, while the lesser omentum is attached to it.—The greater curvature of the stomach is the outline of its distended belly, which rises above the arch of the colon, when the stomach is full, and is marked by the course of the gastro-epiploic vessels.



In the fœtus the stomach lies more perpendicular than in the adult. In the adult, when the stomach is distended the lower orifice is nearly on a level with the upper one; but when the stomach is empty, and subsides, it falls considerably lower; so that whilst the stomach lies across the abdomen, it is also tending obliquely downwards. The ensiform cartilage will be found to present to the middle of the stomach; and the lower

orifice, when in its natural situation, is opposite to the fossa umbilicalis of the liver: the upper orifice is kept constantly in one place from the stricter connection of the œsophagus with the diaphragm.

Both orifices of the stomach present backward, but more especially the upper one, the lower one being pointed backward and downward. By the distention of the stomach the great arch is extended, the orifices are directed more backward and towards each other, and the greater extremity draws upon the œsophagus. By these means I conceive that there is sometimes produced a difficulty of the stomach discharging its contents when greatly distended, the orifices being in some measure turned both from the œsophagus and duodenum.

The stomach being liable to varieties in its degree of distention, the natural relation of parts must be consequently altered. It ought to be particularly recollected, that in the living body the stomach is supported and bound up by the intestines; so that the great curve is forwards: and the broad anterior surface which the stomach presents in the dead body is turned directly upward, and the inferior downward *. By the collapsing of the stomach, and the consequent falling down of the liver, some have explained the sensation of hunger, conceiving that the uneasy sensation proceeds from the liver being allowed to hang upon the broad ligament.† From the great simplicity of mechanical explanation, physicians have eagerly indulged in them; but it will in general be found, that when they are applied to the explanation of the phenomena of a living body, they lead to erroneous notions.

* Thus the gastro-epiploic artery presents directly forward, and has been wounded by a stab here.

† Winslow.

In describing the human stomach as a conical bag, curved, I speak of what we shall commonly observe in the dead body. But sometimes I have found the stomach divided into two sacs, and more frequently have I seen a contraction in the centre of the stomach, from muscular action. The last two subjects for public demonstration I found divided into two sacs. *Riolan* demonstrated this in 1642. *Schneider* and *Dionis* have given us such instances, and *Morgagni* has expressed an opinion that these were not divisions but only contractions of the stomach. In fact, we meet with a permanent, as well as an occasional form of the human stomach, in which there is a division into two sacs.

Sir Everard Home is of opinion that the cardiac and pyloric portions, thus divided, perform distinct offices.

OF THE COATS OF THE STOMACH.

The coats or membranes forming the stomach are the outer, the muscular, the nervous or vascular, the villous, and the three cellular coats. For some of these subdivisions, however, I see no use, nor are they authorized by the natural appearance of the coats of the stomach. When there is a distinction in texture, structure, of function, and where these laminæ can be separated, we shall consider them as coats; but a mere intermediate tissue

of vessels, or the connecting cellular membrane, are improperly considered as distinct tunics.

First coat.—From what has been already said of the peritonæum, it will readily be allowed that the outer coat of the stomach is formed by the peritonæum, a coat common to all the intestines. Were this not sufficiently evident in itself, it might be ascertained by dissecting the peritonæum from the cardiac orifice of the stomach, where it will be found reflected from the diaphragm. This coat is firm, simple in its texture, having no apparent fibrous texture, and smooth on its outer surface, with many minute vessels. Under the peritonæal coat is the first cellular coat, being in fact a short cellular tissue betwixt the peritonæal coat and the muscular coat.

Muscular coat.—The muscular coat of the stomach consists of several laminæ of fibres; less distinct, however, than those of the œsophagus, or, in other words, more loosely and irregularly distributed. *

These muscular fibres of the stomach do not run in an uninterrupted course, but split, rejoin, and form a kind of retiform texture, through which the coats beneath are at intervals discernible. This structure would appear to bestow a greater power of contraction on the stomach. The strong longitudinal fibres which are seen upon the œsophagus form the outer stratum of the muscular coat of the stomach, and they extend from the œsophagus and cardiac orifice in a stellated form along the upper curvature, and downward upon the great end or sacculus ventriculi. Then we have to observe a set of circular fibres, which, forming rings upon the great end, extend over all the stomach, like the circular fibres of the arteries. These fibres do not each encircle the stomach entirely; but while their general direction is circular, they are so interwoven that no one fasciculus can be followed to a great extent. These are called the

* The most general opinion is, that there are three layers of fibres in the stomach. Some describe an external longitudinal series; a middle transverse stratum; and again the internal fibres running longitudinally. See Galeati Acad. de Bologne.

TRANSVERSE FIBRES OF STRATUM; while the deepest layer consists of the continued circular fibres of the œsophagus. These fibres are strong upon the cardiac orifice, and may be presumed to form a kind of sphincter; but they diminish as they are remote from the superior orifice. The lower or pyloric orifice of the stomach, however, is more carefully guarded by muscular fibres; having in the duplicature of the inner coats a distinct circular ring of muscular fibres.

The cellular tissue, being intermingled with the muscular fibres, connects and strengthens them, and gives the appearance of little white lines interwoven with the muscular fibres, and which some have described as small tendons.* There is also to be observed a broad ligamentous band on the two flat surfaces of the stomach towards the pylorus. They are like the bands of the colon, but not nearly so strong or evident. They are formed by the denser nature of the cellular tissue, and more intimate union betwixt the first and second coats.

OF THE PYLORUS.†

The pyloric orifice of the stomach deserves more particular attention. When the stomach is distended and dried, and a section is made of its lower orifice, a delicate membrane appears hung across, and which is perforated with a circular opening. When the stomach is

* See Winslow, sect. viii. p. 57.

† *Quasi januæ custos.*

hardened in spirits, and a section of this part made, the pylorus is seen to be a duplicature or process of the inner coats of the stomach; and by more particular dissection, it will be found that this circular fold or membrane is formed by the drawing of a more powerful fasciculus of circular fibres which guard this lower orifice.*

OF THE ACTION OF THE MUSCULAR COAT.

Upon considering the weakness of the muscular fibres of the stomach, and the membranous nature of the whole coats, it appears that the general action of the stomach is slow, regular, and by no means a forcible contraction; not an apparatus for triturating the food, but merely giving motion to its contents. But regarding the extreme sensibility of the stomach, and the gradual and regular succession of action, much will be found that is worthy of attention.† It would seem that the morsel is sent down into the œsophagus by a succession of actions, preceded by a perfect relaxation; and that when the food arrives at the superior orifice of the stomach, by the same relaxation preceding the contraction, the muscular fibres of the upper part of the stomach yield and receive the food compressed by the œsophagus. Attending to the form of the stomach, we see a provision for the reception of the food into the great sacculated fundus on the left extremity. And here we shall find that there is a greater profusion of vessels for the secretion of the juices of the stomach, and a set of muscular fibres, probably relaxing and yielding to receive the food, and excited to action only when the process of digestion has been in part or entirely accomplished. Often, on dissection, I see the sac or left extremity of the stomach distended, when towards the right extremity it is like the intestine in form. We have proof, that when the food has remained the usual time in the great sac of the stomach, and comes in succession to be presented at the

* See H. P. Leveling de Pyloro. Sandifort Thesaurus, vol. iii.

† See Haller's Experiments. *Opera Minora*, Ventriculi Motus Peristalticus.

lower orifice, if the stomach be healthy, and the change upon the food perfect, the lower orifice is relaxed, and yields to the contraction of the muscular fibres of the stomach, and the contents of the stomach are passed into the duodenum: but if the food has been of an indigestible nature, it is rejected. The pyloric fibres refuse the necessary relaxation, and by the unnatural excitement, an antiperistaltic motion is produced, and the matter is again thrown into the great end of the stomach, or rejected by vomiting.* There is in the natural action of the stomach a stimulus, followed by a regular succession of motion in its fibres, conveying the contents from the upper to the lower orifice of the stomach. Of this excitement and action we are not conscious; but when the action is disordered by an unusual excitement, the lower orifice is not unlocked, the action becomes violent (the reverse of what naturally takes place), and pain or uneasy feelings are produced. Upon this principle may be explained the nausea and vomiting which take place at certain times after eating, when balls or concretions are lodged in the stomach. While the food lies in the greater extremity, or in the body of the stomach, and the ball or concretion with it, there is no great excitement; but when it has suffered the necessary change, and is approaching to the pyloric orifice, this part, being as it were a guard upon the intestines, is suddenly excited, vomiting is produced, and the ball is thrown into its old place in the sacculus or great end.

An attempt has been made to distinguish the affections of the stomach according as they proceed from the vitiated secretion, or the disordered muscular action. For example, it has been said, if there is pain when the stomach is empty, then it is owing to the secretions of the stomach hurting the coat; if there be pain when the stomach is full, or at regular periods after taking food, then is it proceeding from disordered muscular action. This is settling the whole difficulty on too easy

* It would seem that the upper orifice of the stomach has a power of contraction on unusual stimuli being applied. Haller loc. cit. Exp. ccciii.

terms. The functions of the muscular fibre and of the secreting vessels are not thus distinct. The motion of the stomach itself, and the secretions into it, are actions conducing to a general result, and nature has secured the end by combining the means; and vitiated fluids poured into the stomach even by its own vessels, are attended with irregular spasmodic pains.

This great sensibility, producing effects almost like intelligence, is apparent in the more common disorders of the stomach. We shall find the meteorismus ventriculi (the great distention of the stomach by flatus) existing for weeks, and yet the food passing in regular course through its orifices. We shall find very frequently food of difficult digestion lying in the stomach and oppressing it for days, while food more recently received may have undergone the natural changes, and have, at all events, passed through the pylorus into the duodenum.

Owing to the same slow and successive action of the stomach, it often happens that ulceration and scirrhous pylorus, or other obstruction of the lower orifice of the stomach, is attended with pain, nausea, and vomiting, only at stated intervals after taking food; *i. e.* at the time in which the food should be sent into the intestines in the natural course of action.

The muscular fibres of the stomach are excited by stimuli, applied, not to their substance, but to the contiguous coats; and betwixt the delicate surface of the inner coat and the muscular fibres there is the strictest sympathy and connection. The same connection holds in a less intimate degree betwixt the outer coat and the muscular fibres; for when a part on the surface of the stomach of a living animal is touched with acid or stimulating fluids, the part contracts.* The stomach is considered as less irritable than the intestines, because it is alleged that a stronger dose of a medicine is required to prove emetic than to act as a purgative: but we

* "In ea sede quà tangitur, contrahitur, sulcusque profundus nascitur, et rugæ; cibusque aliquando propellitur ut à sede; contracta fugiat. Minùs tamen quàm intestina ventriculus irritabilis est: hinc emetica fortiora necesse est purgantibus." — Haller.

ought to consider that the action thus excited in the intestines is merely an acceleration of their secretions; while vomiting is the interruption of the usual action, requiring such a violent excitement as to invert the natural action.

But there is something more than this: as the function of the stomach differs from that of the intestines, so may the quickness of their action. Thus in the stomach a gradual change is to be produced upon the food, requiring time and a slow degree of motion; but in the intestines there is a greater agitation of their contents, and a quicker action of their coats, to bring the fluids into more general contact with the absorbing surface, and to give greater activity probably to the absorption by the lacteals. I am inclined to think that the stomach is the most irritable part of the body, and susceptible of the most minute distinctions in the nature of the stimuli applied to it.

The phenomena of the living animal, and experiments in those recently killed, sufficiently prove the contractile powers of the two orifices. Experiments have been made which show the powers both of the cardiac and of the pyloric orifices in retaining the contents of the stomach after the œsophagus and duodenum have been cut across. The stomach of a rabbit has been squeezed in the hand after cutting the duodenum, without any of its contents being permitted to escape *; and in similar experiments, the finger being introduced into the lower orifice of the stomach of an animal yet warm, the fibres of the pylorus were found to contract strongly upon it. Upon forcibly compressing the stomach, the food will be made to pass into the œsophagus much more readily than into the duodenum; which is another proof how necessary the natural series of actions is to the relaxation of the pylorus.

Rumination. — As it is found that some individuals ruminate, and that even such a habit may be acquired, it must be right to say a few words on this subject. — In

* See a paper 3d vol. of Sandifort, Thes.
An excellent plate of the Pylorus, given with this Dissertation. — *Morgagni* Adversar. III. IV. de Ventriculi Struct.

the ruminating quadrupeds the food passes into the paunch. The paunch consists of a larger and smaller cavity, and from the lesser cavity the food is regurgitated into the mouth, to suffer mastication. When a second time swallowed, it is let into the third cavity, and from the third it passes into the fourth cavity, and from that into the intestines. The human stomach cannot perform an operation so complicated as this. But the different directions which the food takes in the stomach of the ruminant animals, in consequence of the motions of the muscular fibres closing or adjusting the slits of the œsophagus, or the openings of the several bags, proves to us that many silent and curious operations may be going forward even in the human stomach. Something we might suppose would be learned from the feelings of such men as chew the cud; but it happens that the best recorded instance occurred in one, a mere brute in intellect.* Here the morsel was brought up from the stomach by a very slight effort; it was chewed and swallowed; after a pause another morsel was brought up, and underwent the same process, and was swallowed. He ate his food voraciously and without chewing. There is no history of dissection on record except on the authority of Fabricius ab Aquapendente, who found the œsophagus remarkably muscular.

Of vomiting. — When there is an unusual or unnatural irritation on the stomach, or when it is violently stimulated or opposed in its natural course of action, the motion becomes inverted; and drawing by sympathy other muscles to its aid, the contents of the stomach are evacuated by vomiting. Thus where the food takes changes inconsistent with healthy digestion; or when solid matters lodge in the stomach; or when secretions of the duodenum pass into the stomach, or unusual actions are propagated backwards upon the stomach from the upper portion of the canal; or when emetics are taken, which are unusual stimuli; or when there is inflammation in the stomach, which, from

* By Sir Everard Home.

giving greater sensibility, produces the same effect with more violent stimuli; or when the coats are corroded or ulcerated;—vomiting is produced. That vomiting may be produced by the inverted motion of the stomach and œsophagus alone, is apparent from experiments upon living animals, where the abdominal muscles are laid open, and from cases in which the stomach has lain in the thorax, and yet been excited to active vomiting.* Again, it is equally evident that, when the stomach is excited to vomiting, there is consent of the abdominal muscles, by which they are brought into violent and spasmodic action; not alternating in their action, as in the motion of respiration, but acting together, so as greatly to assist in compressing the stomach: but at the same time, the action of these muscles, however forcible their contraction, cannot alone cause vomiting; nor has the action of these same muscles any tendency to produce such an effect on other occasions, in which the utmost contraction of the diaphragm and abdominal muscles is required to the compression of the viscera. Many have conceived that vomiting is entirely the effect of the action of the abdominal muscles and diaphragm. Such, for example, has been the opinion not only of J. Hunter, but of Duverney, and of M. Chirac in Hist. de l'Acad. des Sciences, 1700. M. Littre opposed this notion, and contended before the Academy, that the contraction of the diaphragm was the principal cause of vomiting. M. Lieutaud in 1752 supported the idea that vomiting is the effect of the action of the stomach. He found, upon dissection in a patient whose stomach had resisted every kind of emetic, that it was greatly distended and become insensible; and concluded that the want of action in the stomach, and consequent loss of the power of vomiting, was a strong proof of the action being the effect of the contraction of the stomach only. There are other more curious instances of disease of the stomach preventing the muscular contraction in any violent degree, and consequently the absence of the

* See Wepfer de Cicuta Aquatica, p. 68.—Sauvage's Vomitus.

usual symptom of vomiting: — an instance of this kind will be seen in Dr. Stark's work. In my Museum I had a preparation of a stomach, in which the walls had become so thick that they could no longer suffer contraction by the muscular fibres; the consequence of which was that, although the inner coat of the stomach was in a raw and ulcerated state, there was no active vomiting.

There is a very curious experiment by M. Magendie which has much puzzled physiologists. He cut out the stomach of a large dog, and substituted in its place a bladder which he fastened to the œsophagus, and having excited *vomiting*, by pouring emetic solution into the veins, the contents of this bladder were discharged as from the natural stomach. The conclusion has been too hastily formed, that the stomach has therefore nothing to do with the action of vomiting. But it ought to be recollected, that the bladder represents a relaxed stomach, whereas the stomach is muscular and active, and capable of resisting the action of the abdominal muscles and diaphragm, unless there be a consent of the action of the stomach and the action of the muscles of respiration. Thus if we could suppose that a man had a distended bladder for a stomach, whilst he exerted himself forcibly and retained his breath the contents would be discharged. So would they if he lay with his belly over a yard-arm. But no such discharge takes place from the natural body, because the upper orifice of the stomach resists! This resistance does not take place in vomiting; and therefore, I say, the stomach has to do with vomiting, in spite of all the cruelties which have been committed. The lower orifice is contracted, the coats of the stomach are contracted, and the upper orifice is relaxed in the act of vomiting: while the power of ejecting the contents is very principally owing to the violent throws and contractions of the abdominal muscles and diaphragm.

The singultus is the partial exertion of the sympathy betwixt the upper orifice of the stomach and the diaphragm, by which a kind of weak spasmodic action is excited in it, but without a concomitant inverted action in the stomach and œsophagus. It is a convulsive and

sonorous inspiration, owing to an irritation of the upper orifice of the stomach and œsophagus, but not exactly of that kind which causes inversion of the natural actions of the stomach. Thus we have the singultus from gluttonous distention of the stomach, from some medicines and poisons, from some crude aliment, or even from some foreign body sticking low in the œsophagus, or from inflammation. The borborigmi and rumination seem to be gentler inverted actions of the upper orifice of the stomach and œsophagus, unassisted by any great degree of compression of the stomach by the abdominal muscles and diaphragm.

The full action of vomiting is preceded by inspiration, which is a provision against the violent excitement of the glottis, and the danger of suffocation from the acrid matter of the stomach entering the windpipe; for by this means the expiration and convulsive cough accompanying or immediately following the action of vomiting, frees the larynx from the ejected matter of the stomach. But the action of the diaphragm is farther useful by acting upon the mediastinum, which embraces the œsophagus, and no doubt supports it in this violent action.

The subject is very interesting, but I must enlarge no more upon it here.

NERVOUS OR VASCULAR COAT OF THE STOMACH.

What Haller calls the nervous coat, is the cellular structure in which the vessels and nerves of the stomach ramify and divide into that degree of minuteness which prepares them for passing into the innermost or villous coat. It may with equal propriety be called the nervous, the vascular, or the great cellular coat.* Taking it as the third distinct coat of the stomach, it is connected with the muscular coat by the SECOND CELLULAR coat, and with the villous coat by the THIRD CELLULAR coat. Strictly, however, it is the same cellu-

* To call it cellular coat, however, would be to confound it with the three cellular coats generally enumerated by authors.

lar membrane, taking here a looser texture to allow of the free interchange and ramification of vessels. When macerated, it swells and becomes like fine cotton, but has firmer and aponeurotic-like filaments intersecting it; it can be blown up so as to demonstrate its cellular structure.* It is in this coat that anatomists have found small glandular bodies lodged, especially towards the extremities or orifices of the stomach.

VILLOUS COAT.—This is the inner coat, in which the vessels are finally distributed and organized to their particular end. It is of greater extent than the outer coats of the stomach; which necessarily throws it into folds or plicæ. These folds take, in different animals, a variety of forms: but they are simple in man: from the œsophagus they are continued in a stellated form upon the orifice, but form no valve here. In the body of the stomach they are more irregular, sometimes retiform, and sometimes they form circles or squares, but they have generally a tendency to the longitudinal direction. In the pyloric orifice the villous coat forms a ring, called the valve of the pylorus, which, however, has no resemblance to a valve in its form or action. This ring is not formed by the inner coat of the stomach alone, but by the inner stratum of fibres of the muscular coat, the vascular and cellular coats, and the inner or villous coat. The effect of all these coats, reflected inward at the lower orifice, is to form a tumid and pretty thick ring, which appears like a perforated circular membrane when the stomach has been inflated and dried; but in neither state is its direction oblique so as to act as a valve. It seems capable of resisting the egress of the food from the stomach, or the return of the matter from the duodenum, merely by the action of the circular fibres which are included in it.

In the inner surface of the stomach of those dying suddenly, and who were previously in health, *plicæ* may be observed more or less distinct according to the state of contraction of the muscular coat of the stomach. But in those dying of disease and with relaxed stomach,

* Winslow, sect. viii. p. 64.

no folds of the inner coat of the stomach are to be seen. The reason of this the reader should comprehend. The matters contained in the stomach after death, being no longer controlled, enter into chymical decomposition, which extricates flatus, and the gas distends the stomach. This distention removes the plicæ of the inner coat, and indeed changes the whole form of the stomach.

The glands of the human stomach are very small, but in great numbers around the termination of the œsophagus. In this description I am looking to the plate of Sir Everard Home. Brunner described the glands of the stomach as seated on the curvatures. Glands are distinctly to be seen in the stomach of birds and many quadrupeds, and in fishes and serpents.* But it is to Sir Everard Home that we owe the most careful observations on this subject. His lectures on this subject delivered in the College of Surgeons had that grave character of investigation befitting the place, while they possessed an interest beyond example.†

Gastric fluid. — There is secreted into the stomach a fluid, which is the chief agent in digestion. The most common opinion is, that it flows from the extreme arteries of the villous coat in general. When pure, it is a pellucid, mucilaginous liquor, a little salt and brackish to the taste, like most other secretions, and having, in a remarkable degree, the power of retarding putrefaction and dissolving the food. It acts on those substances which are nutritious to the animal, and which are peculiarly adapted to its habits.

It seems to be a peculiarity in the human stomach, that it has a greater capacity for digesting a variety of animal and vegetable bodies. But perhaps the natural power of digesting is diminished as the stomach gains the power of dissolving a variety of substances. In other creatures, a sudden change of food excites the stomach to reject it, and the powers of the stomach are found incapable of acting duly on the aliment, though time so far accommodates the gastric fluid to the ingesta,

* Haller. † These Lectures are now published.

that the digestion becomes perfect. Mr. Hunter speaks of the power of cattle eating and digesting their secundines.* I have seen the membranes coiled in the bowels of a cow; but I too hastily concluded this to be the cause of death. I am corrected by the authority of Dr. Jenner and Dr. Adams. The fact is sufficiently ascertained, that the nature of the digestive process may be so far altered that graminivorous animals may be made to eat flesh, and carnivorous animals brought to live upon vegetables. This throws us back from the simple idea which we should be apt to entertain of the nature of the change produced by digestion, viz. that it is chymical. For we see that the nature of the solvent thrown out from the stomach, and its chymical properties, may be changed by an alteration in the action of the coats of the stomach. Thus we are baffled in our enquiries, and brought back to the consideration of the living property, which can so accommodate itself to the nature of the aliment.

The gastric fluid has been collected from the stomachs of animals after death, by sponges which the animal has been made to swallow, or which have been thrust down into its stomach, incased in perforated tubes. And, lastly, it has been obtained by exciting the animal to vomiting, when the stomach was empty; for the secretions of the stomach are then poured out unmixed with food.† Although by these means a fluid may be obtained which may properly be called the *succus gastricus*, yet it must contain a mixture of the saliva, and secretions from the glands of the œsophagus and pharynx, with the glandular secretions of the stomach, and the general vascular secretion from the surface of the stomach. It is a fluid, then, upon which the chymist can operate with no hope of a successful or uniform result. And, indeed, chymistry seems no farther to assist us in forming an accurate conception of the changes induced upon the fluids in the alimentary canal, than that the more perfect, but still very deficient, experience of the modern chymist successfully combats the speculations

* See Observations on Digestion. † By Spallanzani.

of the chymists of former ages. For example, it was formerly supposed that digestion was a fermentation, and that this fermentation was communicated and propagated by the gastric juice. It is now found that the gastric juice has properties the reverse of this; that it prevents the food from taking an acid or putrefactive fermentation; that it acts by corroding and dissolving the bodies received into the stomach; and that it is itself at the same time converted into a new fluid, distinct in its properties.* It is almost superfluous to observe†, that the gastric juice has no power of acting upon the coats of the stomach during life; whether this be owing to the property, in the living fibre, of resistance to the action of the fluid, or that there is a secretion bedewing the surface, which prevents the action, it is not easy to say; but more probably it is owing to the resistance to its action inherent in a living part.‡

Mr. Hunter supposed it necessary that the animal should be in health, immediately preceding death, in order that the secretion of the gastric juice may be na-

* The most curious fact is that property of the coats of the stomach, or of the fluids lodging in the coats of the stomach, by which milk and the serum of the blood are coagulated. It has been found that a piece of the stomach will coagulate six or seven thousand times its own weight of milk. This action seems a necessary preparation for digestion, which shews us that the most perfect and simply nutritious fluid is yet improper, without undergoing a change, to be received into the system of vessels. For example; milk and the white of eggs are first coagulated, and then pass through the process of digestion. See J. Hunter, Animal Economy, Observations on Digestion.

† I do think it a very self-evident fact, notwithstanding Dr. Adams's taunting manner of quoting these words. See that very interesting work on *Morbid Poisons*, preface, xxxvi.

‡ Mr. Hunter is one great authority on this subject, &c.

See also Morgagni Adversar. iii. A. xxiv.

Dr. Adams on Morbid Poisons, preface; and Mr. A. Burns's (of Glasgow) Paper, Edin. Journal, Ap. 1810. Amongst other curious facts stated by Mr. Burns is this, that he has found all the length of the alimentary canal dissolved into a pulpy glutinous mass. I may say that, connected with the discussion, there may enter a question as to what is the cause of a tenderness sometimes to be observed in all the membranes of the body. I have examined the viscera of a negro, where the intestines were particularly tender, but the pericardium and valves of the heart more remarkably so still.

tural and capable of dissolving the dead stomach: but I have found the stomach of children, who have died after a long illness, digested by the secretion of the stomach. See Examples in my Collection.

Of digestion. — By trituration and mastication, and the union of the saliva in the mouth, the food is prepared for the more ready action of the stomach upon it. In the mouth, however, no farther change is induced upon it than the division of its parts. But in the stomach, the first of those changes (probably the most material one) is performed, which by a succession of actions fits the nutritious matter for being received into the circulation of the fluids of the living body, and for becoming a component part of the animal. For now the gastric juice, acting on this fluid mass, quickly dissolves the digestible part, and entering into union with it, produces a new fluid, which has been called chyme, a thick or viscid and turbid fluid. The mass changes its sensible and chymical properties; and when it has suffered the full action of the stomach, by the gradual and successive muscular action of the stomach, it is sent into the duodenum. The food is converted into chyme by the operation of the gastric fluid, by an operation peculiarly animal, a process of life. And the conversion of the food into a new substance is unattended by any chymical change, strictly speaking, if by chymistry we understand the mutual influence of dead matters in forming compounds, or separating and extricating the constituent parts. Animal or vegetable matter in the heat and moisture of the stomach would quickly fall into the fermentations; but the living properties of the stomach prevent this. I speak of the stomach in health; when weak, then the symptom announcing the diminished power is the extrication of gas, or the formation of acids, with oppression and uneasy sensations. The contents of the stomach consist of air, partly swallowed, partly extricated, of the watery secretions of the coats, and of chyme. The stomach being stimulated by fulness, by flatus, and more still by the peculiar irritation of the food prepared by digestion, the muscular coat is brought into action, and the contents of the stomach delivered into the duodenum.

A case is on record which finely illustrates the function of the stomach. A woman was presented in the clinical ward of La Charité to Corvisart, who had a fistulous opening in the left side of the epigastric region, which communicated with the stomach, and through which part of the villous coat of the stomach could be seen, of a vermilion colour, and covered with mucus, and having certain plicæ.

The vermicular undulations of these rugæ of the inner coat of the stomach could be observed. Three or four hours after this woman took food, she felt an irresistible desire to raise the dressings from the fistula. Then flatus was forcibly discharged with the food, which was reduced into a greyish pulp, having neither acid nor alkaline properties. After emptying the stomach, which she washed, by sending through it a pint of infusion of camomile, she found perfect ease. In the morning a small quantity of fluid like saliva, ropy and clear, was found at the orifice. This was probably the gastric fluid; it possessed neither acid nor alkaline qualities.

On her death the hole in the stomach was found eight fingers' breadth from the left extremity, or one third of the whole length of the stomach distant from the pyloric orifice.

From this case we learn, 1. that the stomach is subject to a gentle vermicular motion; 2. that the food received into the stomach is retained three or four hours in the great left extremity of the stomach; 3. that when it has undergone the process of digestion there, it is conveyed, with rather a sudden impulse, into the pyloric extremity of the stomach; 4. that the chyme thus formed has undergone an animal process, becoming neither acid nor alkaline. Contemplating this illustration of the function of the stomach as a digesting organ, with the according action of its muscular fibres above described, a solid ground-work is afforded for the pathology of this organ.

Hunger and thirst.—We are solicited to take food by the uneasy sensation of hunger, and by the anticipation of the voluptuous sating of the appetite, and by the pleasures of the palate. Hunger is considered as

the effect of the attrition of the sensible coats of the stomach upon each other by the peristaltic motion of the stomach and compression of the viscera. This is too mechanical an explanation. If the sensation proceeded merely from such attrition of the coats of the stomach, food received into the stomach would be more likely to aggravate than to assuage the gnawing of hunger: to excite the action of the stomach would be to excite the appetite; and an irritable stomach would be attended with a voracious desire of food. Something more than mere emptiness is required to produce hunger. By some, hunger is supposed to proceed from the action of the gastric fluid on the coats of the stomach; by others it is attributed to the dragging of the liver, now no longer supported by a full stomach. Hunger is like thirst, a *sense* placed as a guard calling for what is necessary to the system, and depending on the general state of the body. Morbid craving may proceed from many causes; a tapeworm has occasioned bulimia, and spirits and high seasoning excite the appetite even when the stomach is full; but natural hunger has reference to the state of the general system.

Thirst is a sensation seated in the tongue, fauces, œsophagus, and stomach. It depends on the state of the secretions which bedew these parts, and arises either from a deficiency of secretion, or from an unusually acrid state of it. It would appear to be placed as a monitor calling for the dilution of the fluids by drink, when they have been exhausted by the fatigue of the body and by perspiration, or when the contents of the stomach require to be made more fluid — the more easily to suffer the necessary changes of digestion.

The change on the secretion of the tongue and fauces from disorder of the stomach, is not, I imagine, a consequence of an influence communicated along the continuous surface. It has its origin in this natural constitution of the parts; the connection which nature has established betwixt the stomach and tongue, betwixt the appetite and the necessities of the system. The state of the tongue, the loose or viscid secretions of the throat and fauces, even the secretion of the saliva, and the irritability of the larynx, are all influenced by the

state of the stomach. The more permanent and demonstrable effects on the tongue are principally attended to; which, perhaps, is the reason that we only know by this that the stomach is disordered, not how it is affected.

The cardiac orifice is the chief seat of all sensations of the stomach, both natural and unusual, as it is the most sensible part of the stomach. Indeed, we might presume this much by turning to the description and plates of the nerves; for we shall find that this upper part of the stomach is provided in a peculiar manner with nerves, the branches of the par vagum.

The sympathy of the stomach with the rest of the intestinal canal, the connection of the head and stomach in their affections, the effect of the disorder of the stomach on the action of the vascular system and of the skin, and the strict consent and dependence betwixt the stomach and diaphragm and lungs, and in a particular manner with the womb, testicle, &c. — and again, the connection of the stomach with the animal economy, as a whole, — must not escape the attention of the student of medicine.

OF THE INTESTINES.

That portion of the alimentary canal which extends from the lower orifice of the stomach to the anus is called the intestines. It is divided into the small intestines, and the great intestines; the small intestines are subdivided into the *duodenum*, *jejunum*, and *ileon*. The great intestines are subdivided into *cæcum*, *colon*, and *rectum*.

The marked difference of function is betwixt the small intestines and the great intestines. But betwixt the form and capacity of the stomach, the form and capacity of the small intestines, and the form and capacity of the great intestines, there is always a certain relation preserved in the different classes of animals.

The small intestines are estimated to be in length 26 feet, or from four to five times the length of the body, and the great intestines one length of the body,

or about six feet. The younger the subject, the longer the intestinal canal. In an infant they were found to be upwards of eleven times the length of the body. In a child of one foot nine inches they were upwards of eight times the length of the body. In a child three feet one inch they were found to be seven times and one half the length of the body.*

Is this difference to be accounted for by supposing that a different food is applicable to the several ages, or is it an increase of absorbing surface accommodated to the necessities of the body while growing?

In the carnivorous animal the whole of the canal is shorter, being about five times the length of the animal: for example, in the lion. In the herbivorous animals the intestines are longer and more complicated, affording means for the retention or the delay of the descent of the food.

Of the small intestines, the first portion is that division extending from the orifice of the stomach to the part where it is encompassed by the mesocolon. It is called the duodenum. †

† DESCRIPTION OF THE FIGURE.

A. The stomach. B B. The duodenum. C. The gall bladder. D. The pancreas and its duct. E. The ductus hepaticus. F. Ductus cysticus. G. The ductus communis coledochus, joined near where it pierces the gut by the pancreatic duct.

* Sir Everard Home's Lectures.

THE DUODENUM

Stands distinguished from the general tract of the small intestines by its shape, connections, and situation. It has been called duodenum, because it was usual to measure its extent by the breadth of twelve fingers. It is greatly larger than any other part of the small intestines; irregular and sacculated; more fleshy; and, although it has fewer plicæ, it is more glandular and more vascular: but its greatest peculiarity, and that which must convince us of its importance in the animal economy, and of the necessity of attending to it in disease, is this, that it is the part which receives the biliary and pancreatic ducts, and in which a kind of second stage of digestion takes place. This intestine takes a course across the spine from the orifice of the stomach. First it goes in a direction downward; then it passes upward till it touches the gall-bladder; then making a sudden turn it descends directly near to the right kidney, and it enters its *vagina*, or in other words, is involved in the mesocolon; and whilst so embraced, it takes a sweep towards the left side, obliquely across the spine, and a little downward. From this description it is obvious that it must be longer than the breadth of twelve fingers; and, indeed, I call duodenum all that portion of the intestine which is above the mesocolon, preferring a natural to an arbitrary boundary*; as in this extent, besides being tied down to the spine by the mesocolon, it has no mesentery, and the peritonæum is reflected off from it, covering it imperfectly. Of these reflections we have to remark the *ligamentum duodeno-renale*, and *ligamentum duodeno-hepaticum* already described.

Although we shall presently treat of the coats of the

* Ruysch calls it "Intestinum digitale, vel intestinum rectum brevissimum." Adversar. Anat. ii.

See a good description of the duodenum by M. Laurent Bonazzoli, in the Transactions of the Academy of Bologna. And the Dissert. L. Claussen. de duodeni situ et nexu. Sandifort, Thes. V. iii. Monro, Medical Essays.

small intestines in general, yet it may not be improper here to observe what are announced as peculiarities in the coats of this first division. The first or peritonæal coat is imperfect, as must already be understood: for it does not invest the whole circumference of the gut; it ties it down more closely, or it merely contains it in its duplicature, while a greater profusion of cellular membrane accompanies this than the other divisions of the intestines. The muscular coat is stronger than that of the jejunum and ileon; the plies formed by the inner coats smaller than those of the other part of the small intestine, and having more of a glandular structure. At the lower part of the first incurvation of the duodenum, the inner coat forms a particular process like to those which are called valvulæ conniventes; and in this will be discovered the opening of the biliary duct, within which also the ductus pancreaticus generally opens.

It is not without some reason that anatomists have considered the duodenum as a second stomach, calling it ventriculus secundus, and succenturiatus; for there is here performed a change upon the food, converting the chyme (as they have chosen to call it), which is formed in the stomach, into perfect CHYLE. But to suppose that the chyme is perfected in the duodenum, is to suppose the biliary and pancreatic secretions necessary to the formation of chyle; a point which is not allowed; for many suppose that the bile is merely a stimulus to the intestines, holding a control over their motions; others, that it is useful only in separating the chyle from the excrement; or again, that the bile is decomposed, part entering into the composition of the chyle, while the other goes into that of the fæces; it seems to bestow upon them a power of stimulating the intestinal canal in a greater degree; and, as the chyle is formed occasionally without the presence of bile, we may be induced the more readily to allow that the bile does not, in the natural actions and relations of the system, enter into the composition of the chyle. At all events, we see that it is the bile which is the peculiar stimulus of the intestinal canal, and that when interrupted in its discharge from

the ducts, the motions of the belly are slow, and costiveness is the consequence.

There are poured into the duodenum, from the liver and pancreas, secretions which have an extensive effect on the system of the viscera; and we must acknowledge that the derangement of these secretions operates as a very frequent and powerful cause of uneasiness, and therefore that the duodenum must often be the seat of uneasy and distressing symptoms. We may observe that, from the course of the duodenum, pain in it should be felt under the seventh or eighth rib, passing deep, seeming to be in the seat of the gall-bladder, and stretching towards the right hypochondrium, and to the kidney, and again appearing as if on the loins. We may observe farther, that from the connections of this portion of the intestine, and from the manner in which it is braced down by the mesocolon, spasm, when flatus is contained in it, will sometimes produce racking pains. Nay, farther, when the irregularities of digestion affect the duodenum, and spasm and indigestion follow; the distention causes it to press upon the gall-bladder, and the pressure and excitement together cause an irregular and often an immoderate flow of bile, which, with the acrid state of the food, produces anxieties and increased pain, inverted motion, and vomiting.

We must not forget, that the inverted action of the stomach draws quickly after it the inverted motion of the duodenum. It may be of consequence to attend to this in the operation of an emetic, for the stomach will sometimes appear to be discharging foul and bilious matter, which we naturally may suppose to have been lodged in it, but which has actually flowed from the duodenum, or has even come recently from the ducts, in consequence of the operation of the vomit.*

From a defect in the natural degree of the stimulating power of the bile, it will accumulate in the duodenum,

* Indeed, vomiting, in consequence of the concussion and compression it gives the whole contents of the abdomen, acting in a particular manner on the liver, affords most powerful means of operating upon the infarction and remora of the blood in the hepatic system.

occasioning anxiety and loss of appetite, and even congestion of blood, and a jaundiced skin: we may certainly affirm that these, at least, are often connected. Such accumulation in the duodenum must be attended with a languid action of the whole canal, and inactivity of the abdominal viscera, because the peristaltic motion is begun here in the natural action of the intestines; and if the proper stimulus be deficient here, so it will probably be in the whole system of the viscera. Hence the necessity of rousing the activity of the liver by evacuating the whole canal.

I may further observe, that it has been the opinion of the most respectable old physicians, those whose knowledge of diseases has been drawn from an acquaintance with anatomy, from the frequent inspection of dead bodies, and the observation of the symptoms during life, that the study of the diseases connected with the duodenum is the most important which can occupy the attention of the medical enquirer.*

OF THE JEJUNUM AND ILEON, OR INTESTINUM TENUE.

The small intestines, under the name of jejunum and ileon, occupy the space in the middle and lower part of the abdomen, the great mass forming convolutions in the umbilical region. The canal of the small intestines is gradually and imperceptibly diminished in diameter as it is removed from the lower orifice of the stomach; so that the diameter of the gut at the termination of the ileon in the caput coli is considerably smaller than where it forms the duodenum. This tract of the small intestines performs the most important function of the chylopoietic viscera (if any can be said to be peculiarly important where the whole is so strictly connected); for here the food is moved slowly onward through a length of intestine four times that of the body, and exposed to a surface amazingly extended by the pendulous and loose duplicatures of the inner coat. Here the fæces are gradually separated from the chyle.

* See Sandifort, vol. iii. p. 288. See Hoffman.

and the chyle adhering to the villi is absorbed and carried into the system of vessels.

The JEJUNUM * is the upper portion of the small intestine. Its extent is two fifths of the whole. Its convolutions are formed in the umbilical region.

The ILEON. — The lower portion lies in the epigastric and iliac regions, and surrounds the jejunum on the sides and lower part, and forms three fifths of the whole extent of the intestine from the termination of the duodenum at the mesocolon to the beginning of the colon. The coats of the ileon are thinner and paler and more transparent than those of the jejunum, and the diameter of the gut is less; the valvular projections of the inner coat are less conspicuous, so that there is less of a fleshy feeling communicated to the touch; and the mucous glands become more apparent in the lower portion than in the upper portion of the small intestine.

There is sometimes found a lusus in the lower part of the ileon before it passes into the colon: a blind pouch *diverticulum*, or *cæcum*, is attached to the ileon, resembling the caput coli. I have found many instances of this, and several specimens may be seen in my Collection. Sometimes there is more than one diverticulum in the course of the ileon.†

THE PERITONÆAL COAT AND MESENTERY.

The peritonæal coat of the small intestines is of the same nature with that of the stomach. It is thin, smooth, and possessing a certain degree of elasticity. On the surface it has a moisture exuding from its pores; and it firmly adheres to the muscular fibres beneath by a very dense cellular substance. Its transparency makes the muscular fibres, blood-vessels, and lymphatics easily distinguishable; and, when it is dissected or torn up, the longitudinal muscular fibres will be found in general

* So named from its being more generally empty.

† These appendices cæcales of the ileon have given birth to a curious question in the pathology of hernia. See " Hernia ab ilii diverticulo." Morgagni, Adv. Anat. iii. "Hernie formée par l'appendice de l'ileon." LITTRE, Mém. de l'Acad. Royale des Sciences, an 1700: Ruysch, Palfin, &c. See cases of anus at the groin in the Museum.

attached to it. Its use is to give a smooth surface, and to strengthen the intestines, and in a great measure to limit the degree of their distention.

The peritonæal coat of the intestine is continued and reflected off upon the vessels and nerves which take their course to the intestine; or, what is the same thing, and indeed is the more common description, the two laminæ of the peritonæum which form the mesentery, after proceeding from the spine and including the vessels, nerves, and glands belonging to the tract of the intestine, invest the cylinder of the intestine under the name of peritonæal coat.*

The MESENTERY is composed of membranes, glands, fat, and the several systems of vessels, arteries, veins, lacteals, and nerves. As in reality it is a production of the peritonæum, it may be said to arise from the mesocolon, or the mesocolon from the mesentery, reciprocally. But at present we may trace the mesentery from the root of the mesocolon — for the jejunum, emerging from under the embrace of the mesocolon, carries forward the peritonæum with it; and the laminæ of the peritonæum, meeting behind the gut, include the vessels which pass to it and form the mesentery. This connection of the small intestines by means of the prolongation of the peritonæum, while it allows a very considerable motion, preserves the convolutions in their relations, and prevents them from being twisted or involved. But it is by the walls of the abdomen that the intestines, as well as the more solid viscera, are supported; for when the bowels escape by a wound, a portion of an intestine will hang down upon the thigh, unrestrained by the connection with the mesentery.

The mesentery begins at the last turn of the duodenum, or beginning of the jejunum. Its root runs obliquely from left to right across the spine. Here it has, consequently, no great extent; but, as it stretches toward the intestines, it spreads like a fan, so that its utmost margin is of very great extent, being attached to a portion of the canal, which we have estimated at four times

* See the Plan of the Peritonæum.

the length of the body. In the middle of the small intestine the mesentery has its greatest extent or breadth; towards the beginning of the duodenum and the termination of the ileon it is shorter, and more closely binds down the intestine.

MUSCULAR COAT OF THE INTESTINES.

The peritonæum is united to the muscular coat by a very delicate and dense cellular membrane; which in the enumeration of the coats we must call the first cellular coat, but which really does not deserve the name of a distinct coat; for, as already said, the outer lamina of the muscular coat is raised with the peritonæum, and adheres intimately to it. The fibres of the muscular coat of the intestines are simpler than those of the stomach; for here there are only two sets of fibres, the longitudinal and circular fibres. The outer stratum consists of the very minute and delicate longitudinal fibres. Indeed, when the system has been exhausted by a long and debilitating illness, with scarcely any excitement of the intestinal canal, these fibres are not to be observed. In a man who has been cut suddenly off by disease, or who has died a violent death, they are more demonstrable; and in diseases where there has been congestion and excited action in the intestines, they become, of course, still stronger and more discernible. The internal stratum of the muscular fibres is much stronger and more easily demonstrated. These fibres will be observed much stronger about the duodenum and upper part of the jejunum; but they become weaker and more pellucid towards the extremity of the ileon. Tracing any particular fibre of the circular stratum, it is found to form only a segment of a circle, a part of the circuit of the intestine. It seems lost amongst neighbouring fibres or cellular connections; but still, taken together, the circular muscular fibres uniformly surround the whole gut.*

To account for that action of the intestines which urges on the food, we may suppose a greater degree of

* Morgagni Adversaria Anatomica iii. Animadversio v.

irritability and activity to reside in the upper portion; where, of course, is commenced that action which is successively propagated downwards, carrying the fæces into the lower part of the canal. Some anatomists have ingeniously imagined that the inner stratum of fibres surrounds the intestine, not in a circular direction, as was asserted by Willis, but obliquely and in a spiral course; from which followed a simple explanation of their effect, since the contraction of the fibre winding lower in the intestine pursued the contents with a uniform, progressive constriction.

Physiologists have made a distinction in the motion which they have observed in the intestines of living animals: the one they call the vermicular, and the other the peristaltic, motion. Upon looking into the belly of a living animal, or of one newly killed, there may be observed a motion among the intestines—a drawing in of one part, and a distention and elongation of another part of the convolution. This motion has some resemblance to the creeping and undulating motion of a reptile, and has got the name of vermicular motion. On the other hand, the direct contraction of the gut by the constriction of the circular fibres is the peristaltic motion. We must not, however, allow ourselves, from the loose expressions of authors, to imagine, that these circular and straight fibres act separately: on the contrary, excited by the same stimulus, they have a simultaneous motion to the effect of accomplishing the perfect contraction of the gut and propulsion of its contents.*

While the stimulus is natural, the contractions of the muscular coat are in a regular succession from above downward, and, the lower part contracting before the upper is completely relaxed, the food must be urged downwards into the lower portion: the lower portion becomes relaxed at the same time that the upper portion is contracted.†

* Neither can I allow that the acting of the longitudinal fibres in one portion of an intestine dilates that which is below, otherwise than through the compression of food and flatus.

† From the experiments of Haller and others, it is proved that the irritability of the intestines long survives that of the heart: that the

ANTIPERISTALTIC MOTION.

When the successive contraction of the muscular fibres of the intestines is opposed in its natural course downward, either by a violent stimulus (the effect of which is to cause a more permanent contraction in the coats, and one which does not readily yield to the relaxation that follows, as in the natural contraction), or when there is a mechanical and obstinate interruption to the contents of the bowels, then is the natural action reversed. This antiperistaltic motion arises thus: a portion of the intestine being constricted, and not yielding to the contraction which, in the natural action of the gut, should follow in order, the gut must be stationary for a time, until the part above that which is contracted becomes relaxed; then the contents of the intestine finding a free passage upwards, and that portion contracting and propelling the matter still upwards and retrograde (since it is opposed by the contraction below), a series of retrograde or antiperistaltic motions are begun and propagated. The course of the action being changed, the contraction of the gut is not followed by the dilatation of the portion below, but by that above. By this means the matter of the lower portion of the intestinal canal is carried into the upper part, and there acting as an unusual stimulus, it aggravates and perpetuates the unnatural action. From experiments it appears, that a permanent irritation will cause an accelerated motion in both directions; that from the point stimulated there will proceed downward the regular series of contractions and dilatations, while the motion is sent upwards and retrograde from the same point of the intestine towards the stomach.* And this observation

intestines are in general in lively motion, when no motion can be observed in the stomach; but that sometimes the motion of the stomach continues longer than that of the intestines. It is proved, also, that the action of the intestine is adequate to the motion downward and the discharge of fæces, without the aid of the abdominal muscles. See *Mém. par Haller sur les Mouvemens des Intestines*; and *Opera Minora*, p. 398.

* Haller, loc. cit., Exper. 424.

the exhibition of medicine and the diseases of the intestines confirm. But, farther, we may observe, that the food is not uniformly moved downwards: it is shifted and agitated by an occasional retrograde motion, thus: —

The portion of the intestine included under A contracts and sends its contents into B. B, contracting, sends its fluid contents in part backward into A, but in a greater proportion into C. While the contents of the middle portion are sent into the lower part in a greater proportion than into the higher division, the tendency of the food will be in its natural course, downward; whilst at the same time it suffers an alternate motion backward and forward; so that it is more extensively applied to the absorbing surface of the intestines.

The stimulus to the intestines is matter applied to their inner coat; and although there is much sympathy in the whole canal, yet, unless there be matter within a portion of the canal, that particular part has little action. Accordingly, when there is obstruction to the course of the aliment, by whatever cause it may be produced, the portion below becomes shrunk and pale, and free from the effects of inflammation; while the part above stimulated by the food, being in a high state of excitement, irritated by the presence of matter which it is unable to send forward, evacuated only partially by an unnatural and highly-excited retrograde action, becomes large, thick in its coats, strong in its muscular fibres,

and greatly inflamed, till it terminate at last in gangrene.*

The unusual excitement of the muscular fibres produces a very curious effect in the intus-susceptio, which is the slipping of one portion of the gut within another. This may be produced by applying acrid matter to the intestines of living animals; and I have no doubt that it has been produced by giving purges too strong and stimulating in cases of obstruction of the bowels. By the contractions of the muscular coat greatly excited, the intestine is not only diminished in diameter, so as to resemble an earth-worm †, but in length also. This great contraction of the outer coats accumulates the vascular and villous coat as if into a heap, which from the compression of the muscular coat is forced into the neighbouring relaxed portion. This first step leads only to a succession of actions; for the fibres of the relaxed or uncontracted part, sensible to the presence of this accumulated and turgid villous coat, contract in succession so as to draw a part of the contracted gut further downwards. If the irritation is done away or ceases quickly, as in the experiments on animals, another turn

* Haguenot gives an experiment illustrating the cause of ileus. He tied a ligature about the intestine of a cat, and found no antiperistaltic motion excited. This is not wonderful: it is the excitement arising from matter within the gut, to which there is no exit, and not the stricture of it, which is the cause of the violent symptoms. Many cases in the Museum will give the young student a correct judgment on this subject.

Vide Scholium sub tit. Calculus insignis Ilii. Observ. F. Biumi. Sandif. Thes. vol. iii.

The figure represents the *intus-susceptio*. A the part above the invaginated portion; B the including portion.

† See Haller's Experiments, *Opera Minora*, and "Dissections of the Atrophia Ablactatorum," with plates, by Dr. Cheyne. Sandifort, vol. ii. p. 381. in Dysentariæ. — Ibid. 244.

of the intestine coming into play distends this, and undoes the intus-susceptio. But if the cause continues, the intus-susceptio is continued; the included part of the gut is farther forced into the other. By these means the vessels going to the included part are interrupted; the villous coat swells more and more; and several feet of the upper portion of the intestine are often in this way swallowed down. It is not, however, in the natural course downward that this preternatural action always proceeds; for as the excitement is violent and unlike the usual stimulus of food, and as we know that an unusual excitement is very apt to cause an inverted action, it often happens that the intus-susceptio is formed by the lower portion of the gut being included in the part above.*

VASCULAR COAT.

The third coat of the intestines is a stratum of cellular membrane in which the vessels of the gut are distributed. It might with equal propriety be called the cellular coat; and is, indeed, what some anatomists have called the third cellular coat. By inverting the gut and blowing strongly into it, the peritonæal coat cracks and allows the air to escape into this coat; which then swells out, demonstrating its structure to be completely cellular.† Its use evidently is to suffer the arteries, veins, and lymphatics to be distributed to such a degree of minuteness as to prepare them for reflection into the last and innermost coat, and for entering into the structure of the villi: for they come to the extremity of the mesentery as considerable branches, but forming in this coat many ramifications, and these subdividing, their extreme branches are finally distributed to the inner coat. This is the coat

* See a case, in which a portion of intestine 18 inches in length, with its connecting mesentery, was discharged by stool; and the dissection, in Duncan's Medical Commentaries, vol. ix. p. 278.

† An experiment to which Albinus attaches much importance. See also, in the Acad. de Bologna, a paper by Mr. D. G. Galeati on the fleshy coat of the stomach and intestines.

in which, in some parts of the intestines, little glands or cryptæ are lodged.

VILLOUS COAT.

The most curious part of the structure of the intestines is the villous or inner coat; for by its influence is the chyle separated from the general mass of matter in the bowels, and carried into the system of vessels. To this all we have been describing is merely subservient.

The villous coat has a soft fleecy surface; and, being of greater extent than the other and exterior coats, it is thrown into circular plaits or folds which hang into the intestine, and take a valvular form. They have the name of VALVULÆ CONNIVENTES. Some of them go quite round the inside of the intestine; others only in part. They are of larger or smaller extent in different parts of the canal: for example, they begin a very little way from the lower orifice of the stomach irregularly, and tending to the longitudinal direction; further down they become broader, more numerous, and nearly parallel: they are of greater length, and more frequent in the lower part of the duodenum and upper part of the jejunum. These valvular projections have their edges quite loose and floating in the canal; and from this it is evident that they can have no valvular action. Their use is to increase the surface exposed to the aliment; to enlarge the absorbing surface; and at the same time to give to it such an irregularity that the chyle may lodge in it and be detained. Into the structure of these plicæ of the villous coat, the vascular or cellular coat enters, and generally in the duplicature a small arterial and venous trunk will be observed to run. That these plicæ are formed chiefly by the laxity of the connection and the greater relative extent of the inner coat, is apparent upon inverting the gut, and insinuating a blow-pipe under the villous coat, for then you may distend the cellular substance of the vascular coat so as entirely to do away the valvulæ conniventes.

The pile or lanuginous surface, from which this coat

has its name, is to be seen only by a very narrow inspection, or with the magnifying-glass. It is owing to innumerable small filaments, which project from the surface like hairs at first view, but of a flat or rounded figure as they are exhibited in a state of fulness and excitement or depletion. They consist (as appears by the microscope) of an artery and vein, and lacteal or absorbing vessels, and to these we may surely add the extremity of the nerve. They have a cellular structure; they are exquisitely sensible; and, when stimulated by the presence of fluids in the intestines, are erected and absorb the chyle. They are the extremities of the lacteal absorbing system, and their structure is subservient to the absorption by the mouth of the lacteal vessel.*

But the surface of this coat is not only an absorbing one, it also pours out a secretion; and, indeed, as a secreting surface, upon which medicines can act, it is to us one of the most powerful means of correcting the disordered state of the system. The fluid which is supplied by the surface of the intestines is called the liquor intericus — a watery and semipellucid fluid, resembling the gastric fluid. This fluid physiologists have affected to distinguish from the mucous secretion of the glands of the inner surface of the intestines; but it is impossible to procure them separate.†

* See further of their structure under the title of the LACTEAL and LYMPHATIC SYSTEM, where the subject of absorption and the structure of the villi is treated. Dr. Hunter and Mr. Cruickshanks observed about fifteen or twenty orifices in each villus. These communicated with radiated branches of absorbents, which together formed the trunk of one of the lacteal vessels.

† It has been supposed that the fluids excreted from the surface of the intestines were furnished by very minute foramina (which are visible by particular preparation) in the interstices of the villi. See the letter of Malpighi to the Royal Society of London, on the pores of the stomach; and the paper by M. Galeati, in the Bologna Transactions, on the Inner Coat, which he calls the Cribriform Coat. These pores, according to Galeati, are visible through the whole tract of the canal, and particularly in the great intestines.

GLANDS.

Anatomists have observed small mucous glands seated in the cellular membrane of the intestines*, the ducts of which they describe as opening on the villous surface of the intestines. They are seen as little opaque spots when the intestine is cut in its length and held betwixt the eye and the light. They have been chiefly observed in the duodenum; few of them in the general tract of the small intestines. Little collections or agmina of glands are observed, which increase in frequency toward the extremity of the ileon. It is natural to suppose, that, as the contents of the intestines become in their descent more acrid and stimulating, there will be a more copious secretion of mucus in the lower intestines for the defence of the villous coat. According as these bodies are found single or in collections, they have been called glandulæ solitariæ or agminatæ. Sometimes they are called glandulæ Peyeri or Brunneri.

FUNCTION OF THE SMALL INTESTINES.

In concluding the view of the small intestines, we cannot fail, I think, to express a correct idea of their function: the matter ejected from the stomach is a greyish, pultaceous, turbid mass. In the small intestines we find that a precipitation or separation of feculent matter has taken place from the nutritious part.

This nutritious matter, called chyle, is a pure milky fluid, and coagulable; so that already the most remarkable character of the circulating blood is assumed by the digested matter. And, what is still more curious, already do we see that consent established betwixt the containing and the contained fluids which is the source of all the actions of a living body. The chylous or nutritious matter from which the feculency is separated is attracted by the surface of the villous coat of the intes-

* Peyerus Biblio. Manget. Brunnerus de Glandulis Duodeni. Morgagni Adversar. An. iii. viii. These he supposed additional pancreatic glands.

tine, and in an animal killed some time after taking food, the matter may be seen coagulated upon the inner surface of the intestine.

Some are of opinion that the *chylification* is produced by the action of the bile, and that the effect of it is to precipitate the effete matter; but I am more inclined to believe that it is the office of the part of the intestines we are now considering to separate, by attraction, the chyle from the mass of ingesta: for supposing that we were to give the office to the bile, that would be a mere precipitation, and could not explain the attraction of the chyle to the villi*, nor the manner in which the fine nutritious fluid was imbibed by the lacteals, while the feculent part is passed down. There is a preparation of the alimentary matter; but is not the absorption by the lacteals like the action of the roots of plants? They must exercise a selection, and possess a power of separating; nor is it more wonderful that the orifices of vessels should affect the morbid fluid, than that they should retain the power we so readily acknowledge them to possess, of separating and changing the blood in the act of secretion.

It is more natural to suppose, that this very peculiar property of life, the coagulation, is bestowed through the influence of the villous surface of the intestine, than produced by the mere pouring in of a secretion like the bile.

OF THE GREAT INTESTINES.

The great intestines form that part of the intestinal canal which is betwixt the extremity of the ileon and the anus. They differ essentially from the small intes-

* In Sir A. Cooper's lectures in the College of Surgeons, this attachment of the chyle to the villi was considered as a discovery; but the statement will be found in former editions of this work.

tines in their size, form, and general character; and in the texture, or at least in the thickness, of their coats.

The great intestine, beginning on the right side of the belly, rises before the kidney; passes across the upper part of the belly under the liver, and before or under the stomach.* Then, making a sudden angle from under the stomach and spleen †, it descends into the left iliac region. Here, making a remarkable turn and convolution, it descends into the pelvis by a curve running in the hollow of the sacrum.‡

The great intestines are accounted to bear a relation to the small intestines as five to twenty-five.

* This turn of the colon from the right across the belly is flexura prima, superior dextra hepatica. Soemmering.

† Flexura secunda, superior sinistra lienalis.

‡ Description of the figure. A the ascending colon; B the transverse arch; C the sigmoid flexure; D the rectum.

The natural division of this portion of the intestine is into the *cæcum*, *colon*, and *rectum*.*

VALVULA COLI. †

The extremity of the intestinum ileon enters, as it were, into the side of the great intestine at an angle.‡ And here there is a valvular apparatus formed by the inner membrane of the gut, which, more than any other circumstance, marks the distinction betwixt the small and great intestines; for, as the effect of this valve is to prevent the regurgitation of the fæces into the small intestines, it marks sufficiently the nature of the change produced on the ingesta in their passage through the small intestine, and how unfit, in their changed and acrid state, they are to be longer allowed lodgement in the small intestines.

DESCRIPTION OF THE FIGURE.

The figure represents the caput coli, dried and cut open.

A The ileon.
B The colon.
C The valve of the colon.
D The appendix vermiformis.

* Some authors divide the great intestine into six parts, enumerating the cæcum, pars vermiformis, the right, the left, and the transverse colon, and the last part or rectum.

† *Valvula Coli*, or *Valvula Bauhini*, or *Valvula Tulpii*.

‡ Of the opening of the small intestine into the greater, see Morgagni Adversar. iii. Animad. xi.

Upon opening the caput coli, or lower part of the colon, on the right side, and examining the opening of the ileon into it, we see a slit formed betwixt two soft tumid plicæ of the inner membrane of the gut: the one of these is superior; the other inferior. They are soft and moveable, and seem scarcely calculated for a valvular action. But there is little doubt that when the great gut is distended or in action, they are calculated to resist the retrograde passage of the fæces into the ileon, though not absolutely to prevent it, as we know from what is vomited in the iliac passion.* In the form of the opening of the ileon, and in the broadness of the valvular membranes, there is considerable variety. The superior valve is transverse, smaller and narrower than the lower one; the lower one is longer, and takes a more extensive curve; and sometimes the lower one is so remarkably larger than the upper valve, that it gives a degree of obliquity to the insertion of the ileon into the colon, so as to approach to that structure which we see in the entrance of the biliary duct into the intestine, or the ureter into the bladder. At their extremities these valves coalesce and run into the common transverse folds of the colon: and this is what Morgagni has called the fræna or retinacula.† At this place of union of the ileon and colon the longitudinal muscular fibres of the ileon are mingled and confounded with the circular fibres of the colon.‡ The circular muscular fibres certainly enter so far into the composition of the valve, that they embrace the margin, and, by contracting during life, must make the experiments on the action of this valve in the dead body less decisive than they would be, were we certain that this valve acts on principles strictly mechanical.

The discovery of the valve of the colon, which, from its action in guarding the ileon, might rather be called the valve of the ileon, has been attributed to many anatomists, chiefly to Varolius, Bauhin, and Tulpius; and it sometimes receives the name of the two latter anatomists.

* Morg. Advers. A. iii. An. ix. Kerckringus Observ. xxxi.
† Animad. xiii. ‡ Winslow.

CŒCUM.

We have seen that the ileon is inserted into the side of the colon: now that portion of the gut which is below this union of the ileon is a round or slightly conical sac, from two to three inches in length. It is attached by cellular membrane to the iliacus internus muscle. It is not a regular sac, but is divided into large cells like those in the rest of the colon, and has some variety of form in different subjects.

PROCESSUS, SEU APPENDIX, VERMIFORMIS.

There is appended to the cœcum a small gut, also blind; but bearing no relation in size or in figure to any part of the intestinal canal. This gut, from its smallness and twisted appearance, like a writhing earth-worm, has received the name of vermiformis. It is somewhat wider at the connection with the great intestine, and stands off obliquely, so that sometimes its inner membrane takes the form of a valve.* It scarcely ever is found containing fæces, but only a mucus excreted from its glands. In the fœtus the appendix vermiformis is comparatively much larger, its base wider; upon the whole, more conical, and containing meconium; and in the young child it often contains fæces. The cœcum and appendix in the human subject are just sufficient, like the form of the teeth, the stomach, and the intestines, generally to show that man holds an intermediate condition among graminivorous and carnivorous animals. The cœcum is one of the many means of retarding the descent of the food through the colon; and it is found long and intricate in such animals as have a colon otherwise calculated to retain their contents. In carnivorous quadrupeds and birds the cœca are short; in the graminivorous quadrupeds and birds the cœca are long.

* Morgagni. M. Laur. Bonazzoli in the Acad. of Bologna.

GREAT DIVISIONS OF THE COLON.

The great division of the colon are these: First, the RIGHT DIVISION of the COLON rises from the insertion of the ileon, and from that part of the great intestine which is tied down by the peritonæum and cellular membrane, and ascends on the right side of the small intestines, until it gets under the margin of the liver, and in contact with the gall-bladder. This part will be found to have some considerable variety in its form, as it is more or less distended. (It is marked A in the figure.)

THE TRANSVERSE COLON.*

The transverse colon is that part of the great intestine which takes a course across the belly, and which generally forms an arch before or immediately under the stomach. (It is marked B.) When this part of the colon, however, is much distended, being at the same time held down by the mesocolon, its angular turns reach under the umbilicus, nay, even to the pelvis.†

The LEFT OR DESCENDING COLON is short: for from the place where the colon begins to bend down on the left side, to those violent turns which it takes before terminating in the rectum, it is but of small extent. Here it is attached to the diaphragm and psoas muscle.

The SIGMOID FLEXURE‡ of the colon C, is formed by a narrowing and contraction, and closer adhesion of the gut to the loins below the left kidney, and to the cup of the ilium, by the peritonæum, which has the effect of throwing it into some sudden convolutions. The colon then terminates in the rectum D.

PECULIARITIES IN THE COLON DISTINGUISHING IT FROM THE SMALL INTESTINES.

The coats of the great intestines are the same in number and in structure with those of the small intes-

* COLON TRANSVERSUM. ZONA COLI.

† For the varieties in the situation of this intestine and the viscera in general, see Morgagni Adversar. Anat. ii. Animadver. ii.

‡ From its resembling the Roman S.

tines; but they are thinner and more difficult to be separated by dissection. The villi of the inner coat are smaller; indeed betwixt the villous coats of the ileon and the cœcum there is a distinction abruptly marked *; the mucous glands or follicles are sometimes very distinct; and, lastly, the muscular fibres have some peculiarities in their arrangement. The most characteristic distinction in the general appearance of the great and small intestines is the notched and cellular appearance of the former. The cells of the colon being formed betwixt the ligamentous-like stripes which run in the length of the gut, have a regular threefold order. These cells give lodgment to the fæces; retain the matter; and prevent its rapid descent or motion to the rectum. Here the fluids are still more exhausted, and the fæces take often the form of these cells. When the great intestines are torpid, and inert in their motions, the fæces remain too long in the cells of the colon, and become hard balls or scybala. But when in this state of costiveness, the intestines are excited by medicine, not only is the peristaltic motion of the intestines increased, but the vessels pour out their secretions, loosening and dissolving the scybala.†

MUSCULAR COAT.

The ligamentous-like bands of the colon form three fasciculi running in the length of the gut: one of these, obscured by the adhesion of the omentum, is not seen without dissection; and the other is concealed by the mesocolon.‡ These bands are formed by the longitudinal fibres of the gut, being concentrated into fasciculi, and not uniformly spread over the general surface, as in the small intestines; and being at the same time more firmly connected with the peritonæal coat, they give the appearance outwardly of ligament more than

* Vide Albin. Annot. Acad. l. vi. c. viii. de intestinis, et tab. ii. f. vii.

† See note of the pores of the intestines.

‡ Stratum liberum, stratum omentale, et tertium mesocolicum.

of muscular fibres.* The inner or circular muscular fibres of the great intestines are like those of the small intestines, uniformly spread over their surface, and are stronger than those of the latter.

RECTUM.

The RECTUM † forms the last division of the great intestines; and I know no better proof of the impracticability of altering the names in anatomy than this, that anatomists have, in almost every age, insisted on the impropriety of calling this gut, which answers in its shape to the curve of the sacrum, a straight gut; and yet always, even to the present day, it is rectum.

From the last turns of the colon, called sigmoid, the gut is continued over the promontory of the last vertebra and sacrum (a little to the left side), and falls into the pelvis. It runs down, in a curved direction, betwixt the sacrum and bladder of urine. In the upper part it is covered by the peritonæum, and has its fatty appendages like the colon, but less regular; and sometimes the fat merely deposited under the peritoneal coat. It is tied down by the peritonæum, in form of mesorectum; but, deeper in the pelvis, it loses the peritonæum, (which, as we have said, is reflected up upon the back of the bladder, and forms here lateral folds,) and the rectum is connected with the lower part of the bladder and vesiculæ seminales by cellular membrane. In women, the muscular fibres of the rectum and vagina are intimately connected. ‡

The muscular coat of the rectum is particularly strong. The fleshy bands of the colon, spreading out, are continued down upon the rectum in an uniform sheath of external longitudinal fibres. The circular fibres of this part of the gut are also particularly strong;

* See Morgagni. See also Galeati on the fleshy coat of the stomach and intestines, in the Memoirs of the Acad. of Bologna.

† The name *rectum* is taken from the old anatomists, who described from brutes. A professor of Edinburgh calls it *curvum*, but this I cannot admit after reading Morgagni Epist. Anat. xiv.

‡ Winslow.

and towards the extremity, appearing in still stronger fasciculi, they obtain the name of sphincter, of which three are enumerated; and this, to distinguish it from the others, is called the intestinal or orbicular sphincter.

The internal coat of the rectum does not deserve the name of villous, nor of papillaris. Its surface is smooth, and there are often distinctly seen little foramina like the mouths of ducts or follicles, in part the source of the mucous discharge, which is sometimes poured out from this gut. Towards the anus the folds become longitudinal, and terminate in the notched-like irregularities of the margin.*

FUNCTION OF THE GREAT INTESTINES.

One obvious use of the great intestines is to be a receptacle for the useless part of the food, that the matter descending through the small intestine may not be voided as it descends. In the next place we see, that, in proportion as the quantity of the ingesta is great to the really nutritious part, the great intestines are capacious and long. Thus in the goat, the great intestines are twenty feet nine inches in length, while in the lion they are three feet eight inches†; which is an increase of length of intestine in the herbivorous animal more than in the carnivorous, by as much as the quantity of the useless part of the vegetable food is great in proportion to the animal food.

Mr. Cooper, in his lectures to the College of Surgeons, gave the most diverting reason for the colon of sheep, and some other animals, being of a form calculated to retain the fæces, and form them into round dry pellets. The fact is, that it is in the colon that the water is absorbed, for the necessities of the system. These animals, inhabiting lofty, dry, and sandy places, or extensive plains, have this structure of the great intestines to enable them to extract the whole moisture

* The presence of stricture within the anus seems to have given rise to the idea of there being a valve here. Morgagni Adversar. An. iii. Animad. vi.

† Sir Everard Home's Lectures.

from the food, and, consequently, the less frequently to require drink.

Professor Coleman has observed, that the water drank by a horse is very quickly conveyed through the canal, and deposited in the great intestines.

It is matter of daily proof, that the aliment is deposited in the right colon liquid; that in arriving in the rectum it is deprived of fluid; and that the lymphatics of the great intestine are found distended with a limpid fluid. From such views I have entertained the opinion, that a very principal office of the great intestines was to imbibe the fluid from their contents in proportion to the wants of the system.

But there is another office obviously performed by the intestinal canal,—secretion, or rather excretion. The surface of the intestine is the organ by which that matter (the waste incident to the changes of the economy), which is not carried away in the urine, is thrown out of the system.

The fæces contained in the great intestines, though offensive, are not putrid; and the rapid change which takes place in the matter by chymical combination, when voided, implies that there is a controlling influence of the great intestine over its contents. Hence we may believe, that, in derangement of function of the bowels, this controlling influence being lost, such chymical change or putrefaction may take place in the contents of the colon, as to render them a new source of morbid irritation.

Not being satisfied with the observations I have met with on the different gases found in the intestinal canal, I may be excused omitting to notice them in a book of anatomy.

OF THE SOLID OR GLANDULAR VISCERA OF THE ABDOMEN.

The solid or glandular viscera of the abdomen are the liver, the spleen, the pancreas, the kidneys, the glandulæ capsulares.

OF THE LIVER.

Our attention is first drawn to the liver, as it holds in so eminent a degree the sovereignty over the motions of the intestinal canal, and as it is so strictly connected with it by its system of vessels, and by its functions. The liver is the largest viscus in the body; and as in its size and proportion to the whole body it is great, so are its connections in other respects with the whole system very intimate. This is particularly evident in the diseases of the liver, and was the cause of the ancients ascribing to it so eminent a place in the economy.

In all ages authors have paid particular attention to the liver, and have exercised their ingenuity in giving various explanations of its function. The ancients made it the supreme director of the animal system. They supposed that they could trace the nutritious fluids of the intestines through the meseraic veins into the porta and into the liver, and that it was there concocted into blood. From the liver to the right side of the heart they found the cava hepatica carrying this blood, as they supposed, already formed in the liver, to the centre of the system in the heart; and through the veins they supposed the blood to be carried to the remote parts of the body. All this, it is well known to my reader, is error.

Seat of the liver.—The liver is seated in the upper part of the abdomen, under the ribs, and towards the right side, or principally in the right hypochondrium. In the fœtus it occupies more of the left side than it

does in the adult. Indeed it is nearly equally balanced in the fœtus, but the older the animal (at least during the first five years) the greater will be the proportion of it found in the right side.

Without going into the more minute subdivisions of this viscus, we may observe, that it is more uniform and smooth, and convex on the upper surface; on the lower, more irregularly concave. Its upper surface is applied in close contact to the concavity of the diaphragm, and in the fœtus its margin is in contact with the abdominal muscles, because it falls lower than the margin of the ribs. Its lower and concave surface receives the convexity of the stomach, duodenum, and colon. In a healthy adult subject, the liver does not extend from under the margin of the ribs, unless near the pit of the stomach, but in the fœtus and child it is much otherwise. In a fœtus of the third and fourth month the liver almost fills the belly: it reaches to the navel, covers the stomach, and is in contact with the spleen. After the seventh month other parts grow with a greater rapidity in proportion. Indeed some have affirmed, that the liver, or at least the left lobe, actually decreases towards the time of birth.* But from this time to the advance to manhood the chest becomes deeper; the sternum is prolonged, and the diaphragm becomes more concave; so that the liver retires under the margin of the ribs, and its edge on the left side in the adult reaches no farther than to the œsophagus. When the liver becomes scirrhous and enlarged, its hard margin comes down so as to be felt through the abdominal parietes under the border of the chest. This enlargement of the liver, and consequent descent of its margin, is to be felt more easily by grasping the integuments of the belly, as if you expected to lift up the acute edge of the liver, than by pressing with the point of the finger. By this means we shall be sensible of the elasticity and softness proceeding from the intestines, below the liver, and of the resistance and firmness of the margin of it. The physician, however, should not forget, that the

* M. Portal Acad. des Sciences, 1773.

depression of the diaphragm, and consequent protrusion of the liver by disease in the thorax, gives the feeling of an enlargement and hardening of the liver. The left great division of the liver is perhaps as often diseased and enlarged as the right, in which case, it is more difficult to ascertain it by examination.

Neither should a physician be ignorant, that by suppuration in the lungs, and consequent rising of the diaphragm, the liver is elevated considerably, so as to retire farther under the protection of the false ribs. It is a most common error in practice, for the physician to mistake the square contracted portion of the right rectus for the enlarged liver.

M. Portal, by running stilettos into the belly of the subject as it lay upon the table, or was raised into the perpendicular posture, found that in the latter posture the liver shifted two inches. But it is almost superfluous to remark concerning these experiments, that they are by no means conclusive. In the dead body, the abdominal muscles are relaxed: they yield to the weight of the viscera; and the diaphragm is pulled down by the weight of the viscera. The margin of the liver necessarily falls lower, but in the living body there is a close and perfect bracing of every part by the abdominal muscles: they do not yield, and very little if any alteration can take place in the situation of the viscera.

It must be observed, however, that a considerable motion of the liver is a consequence of respiration, and of the action of the diaphragm. This motion is chiefly on the back part of the right lobe of the liver. The left lobe being more on the centre of the belly, and, consequently, opposite to the centre and less movable part of the diaphragm, it is less affected by the respiration than the larger right lobe.

LIGAMENTS OF THE LIVER.

The peritonæum is reflected in such a manner from the neighbouring parts upon the liver as to form membranes receiving the name of ligaments. It has been explained, however, that these are not the sole support

of this viscus; and that the compression of the surrounding abdominal muscles is the principal support of the liver, as it is of the other viscera.

The BROAD LIGAMENT * of the liver is formed by two laminæ of the peritonæum, connected by their cellular membrane, descending from the middle of the diaphragm and point of the sternum, to the convex upper surface or dorsum of the liver. This ligament is broadest where it passes down from the point of the sternum to the fossa umbilicalis; but, as it retreats backwards, it becomes narrower, and is united to the coronary ligament, near the passage of the vena cava. This circumstance, with the curve which it naturally takes on the surface of the liver, gives it the shape of the falx.

LIGAMENTUM TERES. — The round ligament of the liver is the firmer ligamentous cord, which may be traced from the umbilicus along the peritonæum into the duplication of the broad ligament, and into the fossa umbilicalis. It is formed by the degenerated coats of the great vein, which brings the florid blood from the placenta into the veins of the liver, and from thence into the right side of the heart of the fœtus. †

The CORONARY ligament of the liver is formed in consequence of the attachment of the liver to the diaphragm. The attachment is of course surrounded by the inflection of the peritonæum from the diaphragm to the liver. It is called the coronary ligament, though it has been observed that this attachment of the liver is not circular, but of an oval or very oblong shape.

The LATERAL LIGAMENTS are formed by the peritonæum continued laterally. The right lateral ligament, like a mesentery, attaches the right and great lobe of the liver to the diaphragm, and the left lateral ligament connects the left lobe with the diaphragm, and with the œsophagus and spleen.

* Ligamentum latum suspensorium, falciforme.

† See Vol. II. p. 39. and Plan, p. 43.

FORM AND DIVISIONS OF THE LIVER.

The liver is convex and smooth on the upper surface; concave and more irregular on the lower part; thick and massy behind and towards the right side; but anteriorly and towards the left side it is thin, and has an acute edge, so that it lies smooth over the distended stomach.

Great right and left lobes of the liver. — The first great division of the liver is marked on the convex surface by the broad ligament; which running back from the fossa umbilicalis divides it into the two great lobes, the right and left. When the concave surface of the liver is turned up, we see the same division into the right and left lobes, by a fissure, which runs backwards.

It is on this lower surface of the liver that we have to mark the greater variety of divisions in this viscus. Farther, it is on the right lobe that those eminences are to be observed, which, with the indentations and sulci, give some intricacy to this subject.

Lobulus Spigelii.* — The lobulus Spigelii is betwixt the two greater lobes, but rather belonging to the right great lobe. From its situation deep behind, and from its having a particular papilla-like projection, it is called lobulus posterior, or papillatus. To the left side it has the fissure for the lodgment of the ductus venosus; on the right, the fissure for the vena cava; and above, it has the great transverse fissure of the liver for the lodgment of the cylinder of the porta: obliquely to the right, and upwards, it has a connection with the lower concave surface of the great lobe by the processus caudatus, which Winslow calls one of the roots of the lobulus Spigelii. Its situation is within the circle or bosom of the lesser curve of the stomach.

Lobulus caudatus.† — This really deserves the name of processus caudatus, for it is like a process of the liver, stretching downward from the middle of the great right lobe to the lobulus Spigelii. It is be-

* *Lobulus posterior — posticus — papillatus.*

† Processus caudatus.

hind the gall-bladder, and betwixt the fossa venæ portarum and the fissure for the lodgment of the vena cava.

Lobulus anonymus * is the anterior point of the great right lobe of the liver; or others define it to be that space of the great lobe betwixt the fossa for the umbilical vein and the gall-bladder, and extending forward from the fossa for the lodgment of the porta to the anterior margin of the liver. Sometimes there is a projecting lobe on the margin of this part of the liver, and also there occurs a small projection on the left great lobe which acquires the name of lobulus lobi sinistri.

Sulci, and depressions of the liver.—On the lower surface of the right lobe there may be observed two slight excavations, formed, as it were, by the pressure of the colon and of the kidney. On the lower surface of the left lobe there may also be observed depressions answering to the convexities of the stomach and colon. But these are only the slighter irregularities which might pass unnoticed. There are, besides these, deep divisions which pass betwixt the lobes and lobuli, and indeed form these eminences.

Umbilical fissure.†—From the anterior point of the two lobes there passes backwards to the left side of the lobulus Spigelii a deep fissure, which in the fœtus gives lodgment to the umbilical vein, and which in the adult receives the round ligament, where it is about to terminate in the left division of the vena portæ. The back part of this fissure gives lodgment to the ductus venosus in the fœtus. This fissure divides the liver into its two right and left divisions, and upon the right side joins the transverse fissure.

The transverse fissure is that which passes above the lobulus Spigelii and lobulus quadratus; the processus caudatus, and the lobulus lobi sinistri. It is in this fissure that the great transverse division of the vena portæ lies.

* Lobulus accessorius — anterior — quadratus.

† Horizontal fissure, fossa longitudinalis, longa, anterior.

The POSTERIOR FISSURE * gives lodgment to the ductus venosus. It is a division in the posterior margin of the liver betwixt the left lobe and the lobulus Spigelii, and great lobe on the right. Sometimes, instead of the fissure or sulcus, there is a canal, as it were, in the substance of the liver.

The fourth great fissure is that for the lodgment of the vena cava. It sometimes is called, in contradistinction to the last, the right fissure, or the FISSURA VENÆ CAVÆ. It is a large deep division betwixt the lobulus Spigelii and the back part of the right lobe, for receiving the vena cava as it passes up upon the spine.

The gall-bladder being sunk in the substance of the liver, the pit or excavation which receives it has been considered improperly as a fissure or fossa.† There likewise occur irregular fissures in the substance of the liver, which are like the cuts of the knife, and hold no regular place.

OF THE VESSELS OF THE LIVER, AND OF THE CIRCULATION OF THE BLOOD THROUGH IT.

There belong to the liver five distinct systems of vessels: these are, the vena portæ; the arteria hepatica; the vena cavæ hepaticæ; the lymphatics; and the biliary ducts.‡ These, with the nerves, form a very intricate system of vessels, but a lesson of the most particular importance to the physician. Before speaking of the connections which these vessels constitute with particular parts, or with the entire system, we shall take a view of their origin and course.

THE VENA PORTÆ.

This vein is divided into two parts; that which belongs to the intestines, and which, ramifying on the

* Or sulcus ductus venosi, the left fissure.

† It is generally called *fossa fellis*, or *vallicula vesiculæ felleæ*.

‡ And we might add, the arteries of the outer membrane of the liver which arise from the internal mammary, phrenic, epigastric, and even the spermatic arteries.

mesentery, receives the blood of the mesenteric arteries; and that part which branches in the liver, and distributes there the blood which it has received from the arteries of the membranous viscera. Even from this division, we see that the vena portæ has a very particular distribution; that while it is collecting its branches from the spleen, stomach, and intestines, like the veins in the other parts of the body, into a trunk, this trunk, instead of leading directly to the heart, or uniting with other veins in their course to the heart, enters the liver, and, like an artery, spreads into minute ramifications; hence it is called the vena arteriosa. It resembles an artery in this also, that it has no valves like other veins.

To be more particular; the vena portæ takes its origin from the extreme branches of the cœliac, upper and lower mesenteric arteries. The roots of the portæ answering to these arteries are the splenic vein; the gastro-epiploic vein which runs upon the great arch of the stomach; the mesenteric vein returning from the small intestines; and the right and middle colic veins, and internal hæmorrhoidal vein and left colic returning upon the mesocolon. These, answering to the three great branches of the abdominal aorta, pass obliquely upward in three great divisions, and unite with some lesser veins, as the coronary and smaller veins of the stomach, and pancreatico-duodenalis. The trunk of the vena portæ is now involved in the irregularly reticulated web of the hepatic vessels, arteries, veins, glands, lymphatics, nerves, and biliary ducts, with their cellular membrane. It passes upward somewhat obliquely to the right, and enters the PORTA * or the sinus betwixt the processus caudatus and lobulus Spigelii.

When the vena portæ has entered the liver it divides into two great branches, which, running directly transverse, and being of large capacity, are sometimes called the cylinder of the vena portæ. Of these two great branches of the vena portæ within the liver, the right is

* Sometimes it has been found divided before entering the liver. It has been also found to divide into three branches, in which cases (says Haller), two go to the left side.

greater in diameter, but shorter*: it ramifies in the great right lobe of the liver. The left is longer considerably, and filling the transverse fissure, it is reflected up into the umbilical or horizontal fissure, and is given to the left lobe, to the upper and more anterior part of the right lobe, viz. lobulus anonymus, and to the lobulus Spigelii.

The minute ramifications of the vena portæ every where pervade the substance of the liver, and inosculate with the veins of the surface belonging to the peritonæal coat. The blood of the vena portæ is received into the extremities of the venæ cavæ hepaticæ.

ARTERIA HEPATICA.

For the course of this artery, from the root of the cœliac artery to its entrance into the liver, see the description of the arterial system. The arteria hepatica and the venæ portæ are supported by the same sheath, the lesser vessel encircling the greater, like a tendril. While they have distinct functions, both terminate in the same returning veins; that is to say, whether we admit that one or both open into the biliary ducts, yet they have the same relation to the venæ cavæ hepaticæ which the arteries of the other parts of the body have to their returning veins.

VENÆ CAVÆ HEPATICÆ.

We have seen that the right auricle of the heart is close to the diaphragm above, and that the liver adheres to the lower surface of the diaphragm. We have also found that there was a groove in the back part of the liver for the transmission of the vena cava abdominalis. Now, as the vena cava ascending from the lower parts of the body to the heart is perforating the diaphragm, it is joined by two large veins from the liver, which, from their size and form, being the returning veins of the liver, are termed in general the venæ cavæ hepaticæ.

* Into this branch sometimes the vein of the gall-bladder enters.

These veins sometimes pierce the diaphragm, together with the cava abdominalis, so that there is to be observed one large perforation in the diaphragm; but generally they pass the diaphragm close to the great vein, but so that there are three openings in the diaphragm. When these hepatic veins are traced into the substance of the liver, they are seen to be gathered together from all parts of the liver in two, or sometimes three, great branches.

The communication betwixt the vena portæ and the venæ cavæ hepaticæ are so free, that several anatomists have imagined a peculiar and more immediate communication of their branches than holds in other parts of the body betwixt the arteries and veins; a circumstance which appeared to them the more necessary, considering the lesser impetus with which the blood flows in the vena portæ than in the arterial system.

BILIARY DUCTS.

The smallest subdivision of the substance of the liver is called acinus, and that molecule is supplied with a branch of the venæ portæ, arteria hepatica, and vena cava hepatica. With these there is also seen a minute ramification of the excretory duct of the liver. These last minute branches are the branches of the biliary duct; for they, running into each other, form trunks resembling the branches of veins, and these attaching themselves to the sides of the vena portæ form the greater trunks, answering to the right and left side of the liver. These two branches of the hepatic duct approaching each other, unite, and their union forms the hepatic duct, or ductus choledochus.

When the duct of the liver has advanced a little way from the transverse fissure, it is joined by the CYSTIC DUCT, or perhaps we should rather say, considering the use of the cystic duct, that it is reflected from the hepatic at an acute angle to the right side. The DUCTUS CYSTICUS is much smaller than the hepatic duct; it forms an acute curve near the gall-bladder, and takes a very sudden turn downward, as is seen in the marginal plate.

The hepatic duct, after being joined by the cystic

duct, continues its course under the name of ductus communis choledochus, or common duct.* Now become somewhat larger, it takes its course under the head of the pancreas to the back part of the duodenum, about five inches from the pylorus.

Before it enters the gut, or more generally while included in the coats, it is joined by the pancreatic duct. Having pierced the muscular coat, it runs for some time in the cellular coat, in the length of the gut, and then opens upon the eminence of a considerable valvular plica of the inner coat.

This hole is regularly limited, and by no means equal to the diameter of the duct, either where it is contained within the coats of the gut, or in its course from the liver to the gut. Sometimes the hepatic and pancreatic duct open by distinct perforations.

The outer coat of these ducts is smooth and strong †; within this a cellular and nervous coat is described ‡, and muscular fibres imagined; but the inner coat is worthy of attention. It is reticulated in such a way, that a probe pushed up the duct is caught by their valve-like action.

GALL-BLADDER.

We have already noticed, that the gall-bladder is attached to the lower surface of the right lobe of the liver, and partly buried in its proper sinus: it has sometimes occurred that it was merely suspended to the liver by a membrane like a mesentery. It is a bag of a pyriform shape: its greater end or fundus is contiguous to the colon; its lower end or neck to the duodenum.§ It

* Ductus choledochus, hepatico cysticus.

† Although this coat resists in a considerable degree the distention of the duct, when blown into or injected, yet the whole coats are sometimes so distended as to admit the thumb. But this is rather to be considered as growth and enlargement, than distention.

‡ By Haller.

§ The gall-bladder has been observed wanting; in which case the dilated ducts would seem to have been capable of retaining a quantity of bile ready to be evacuated into the intestine. A double gall-bladder has sometimes been found.

is generally of a size to contain an ounce, or an ounce and a half, of bile.

The coats of the gall-bladder are the outer peritonæal coat: a middle cellular coat, which from its analogy to that of the intestines we should call vascular coat; and an inner coat. In the intermediate coat muscular fibres have been looked for with great eagerness, but none have been demonstrated, although a conviction remains that there are muscular fibres in the composition of the coats of the gall-bladder. This coat gives form, limit, and strength to the gall-bladder. The third or inner coat is formed into innumerable rugæ, so as to take a cellular or reticulated texture. These loculi, as we may call them, thus formed by the duplicature of the internal membrane, are of considerable variety in shape, square, round, or triangular. These rugæ, and the whole internal membrane of the gall-bladder, have a beautiful and minute net-work of vessels upon them; and in these cells there can be little doubt that there are small mucous follicles or pores, or that an exudation from extreme vessels sheaths the surface from the irritation of the acrid bile. The extreme degree of vascularity and reticulated texture of this inner coat of the gall-bladder is not apparent before the sixth or seventh month of the fœtus, and then it takes a peculiar texture in preparation for the reception of the secreted bile.

Towards the opening of the bladder into the cystic duct the rugæ assume a semilunar figure, and seem to have a valvular action, in at least so far that they seem intended to give a degree of difficulty to the passage of the bile. The same structure of the internal coat prevails in the cystic duct.

However strange it may appear, considering the relation of the liver as a gland to its ducts, and to the gall-bladder as a receptacle of the bile, an opinion was entertained that the bile of the gall-bladder was secreted by its own coats, and that it was of a different nature from the bile conveyed from the substance of the liver. Without further argument it is sufficient to say, that when the cystic duct is tied, or when it is preternaturally obstructed, there is no bile secreted into the gall-bladder.

From the connections of the gall-bladder, and from the considerations of the whole anatomy, there can remain no doubt that the gall-bladder is a mere receptacle, reserving a sufficient store of this fluid for the due change to be performed upon the food; that as the stomach is not at all times loaded with food, nor the chyme and fluid from the stomach incessantly passing through the duodenum, neither is the bile at all times running from the gall-ducts. On the contrary, as the stomach is emptied of its contents at stated intervals, the gall-bladder affords a provision for a quantity of bile to be evacuated proportioned to the food, which is passing the duodenum. Whether we should conceive that this is a necessary consequence of the retention of the bile in the gall-bladder, or a provision of nature, I am uncertain; but it appears, that the longer the bile is retained, or the longer the fast and the deficiency of food in the duodenum, the more acrid and inspissated is the bile, and the greater also in quantity. This inspissation of the bile takes place in consequence of the activity of the lymphatics, which, ramifying on the coats, absorb the thinner part of the bile.

The rugæ of the inner coat of the gall-bladder may be a provision for extending the surface either for absorption or secretion; but I rather imagine that they are merely a provision for permitting extension more freely.

The gall-bladder is supposed, by some, to be emptied by the general pressure of the abdomen; an opinion founded on a mistake, which a very little consideration might correct. Some think that the stomach, or duodenum, or colon, being distended by the food, compresses and empties the gall-bladder; while others, with more apparent correctness, allege, that it is emptied in consequence of a consent of parts. With the latter I would confidently affirm, that as the aliment passes the duodenum, the bile follows apace, either from the alternate contraction and relaxation of the duodenum occasioning a relaxation of the orifice of the ducts, or, more probably, from the ducts being excited, as the salivary glands are excited by the presence of sapid bodies in the

mouth. By want and hunger, the gall-bladder is allowed to be distended; there is no call for its evacuation.

Experiments would even teach us, that the gall-bladder has not the same irritability, excitable by stimuli applied to the coats, which the stomach, intestines, or bladder of urine have; which is a proof that, like the iris and many other parts of the body, its action is roused more powerfully by indirect stimulus, and through consent of remote parts, rather than by the distention of its coats; whereas the intestines and bladder have it in their constitution to be excited to contraction by simple distention.

From experiments it would appear, in confirmation of what is here alleged, that while the food is in the stomach little bile is discharged; but that it flows when the matter is passing the duodenum, so that a great quantity is then found in the gut. On the contrary, in a state of want and hunger, the gall-bladder is greatly distended, and yet little bile flows from it; although it is not only more in quantity, but more acrid and bitter.*

That the gall-bladder is not destitute of irritability and the power of contraction, would appear from many cases, where, like the urinary bladder, it contracts upon concretions, and becomes thick in its coats.

The retention of the bile, surcharging the ducts, and distending the gall-bladder, and the sudden discharge of accumulated bile, and the irregularities of its course when influenced by disorder of the viscera, are the sources of the most severe and distressing symptoms.†

In the dead body we see the colon and duodenum, or whatever parts lie in contact with the gall-bladder, stained with bile; but this evidence of transudation which is found in the dead body is not seen in the living; while the stain from the bile is observed to be

* Anat. generale de Xav. Bichat, tom. iv. p. 6.

† We have examples of this in a Treatise on the Diseases of the Bowels of Children, by Dr. Cheyne.

A veterinary pupil has just informed me of some experiments he has been making. He destroyed sensation by injuring the medulla oblongata. He then opened the abdomen, and the dog being kept alive by artificial respiration, he saw the peristaltic motion of the intestines very distinctly; but on tying the gall-ducts, these motions soon ceased. This must be confirmed by further observation.

deeper and more extensive in bodies some time dead. It is therefore another example of the peculiar property inherent in the living fibre, which prevents transudation *; the fluids which appear as if exuding from the living surfaces are really discharged from organic pores, or from the extremities of vessels by a living property.

OF THE MINUTE STRUCTURE OF THE LIVER.

The liver is firmer and dryer in some degree, than any of the other viscera; the intertexture of membrane is weak, and in consequence the substance of the liver is friable and easily torn; I have seen death many times from rupture of the liver, consequent on falls and shocks. When cut or torn, it seems for the greater part vascular; or it displays the mouths of innumerable ducts and vessels, and, after a minute injection, the blood-vessels seem to pervade every particle, even when examined with the microscope.

This texture of vessels, in which we may say the substance of the liver chiefly consists, is surrounded with a delicate membrane, the continued peritonæum. It retains the character of peritonæum, in being a simple membrane, whitish, and a little pellucid. In this membrane minute arteries and veins ramify, which are unconnected with the internal system of vessels. In the close cellular membrane beneath it the lymphatic vessels take their course.

* The peculiar odour of the intestines of a dead body is not perceptible in the living: when in dissection the fingers touch the intestines, they retain the odour long; but on handling the intestine in the operation for herniæ, the bad smell does not attach, nor is it at all perceptible. Poison in the stomach of an animal will pervade the coats and affect the whole substance, if permitted to remain after death: but if the stomach containing the berries of the lauro-cerasus be taken from the pheasant of America, they are wholesome food. The peccary, or Mexican hog, when killed, must have the dorsal gland immediately cut out, or the disagreeable smell of this secretion makes the flesh unfit to be eaten. For the same reason, the Indians cut away the noxious glands from the Skunk immediately when killed. All these examples show that the living substance resists the contamination, but that when the parts are dead they no longer resist the percolation of the fluid, the colouring or odorous matter.

For much of the anatomy of the liver, and of the bile, see Morgagni Adversar. An. iii. A. xx. to xxvii.

When a section is made of the liver, the vessels may be distinguished: the ducts by the thickness of their coats, and their yellow colour; the arteries by a less degree of thickness, and a more resisting elasticity; the branches of the vena portæ and the cavæ hepaticæ by the thinness of their coats, of which those of the latter are considerably the weaker.

The vascular tissue of the body of the liver has no communication by vessels with the investiture of the peritonæal coat of the liver.* It is therefore considered as a peculiarly distinct organization. By proofs drawn from anatomical injections we are informed that there is a free intercourse through the extreme branches of all the five systems of vessels in the liver. By making minute injections and sections of the liver, there seems no likelihood of gaining information of the structure and connections of these vessels. Walther, who seems to have examined this matter more methodically and minutely than any other anatomist in any age, could make no distinction of parts. In whatever way he made his sections, whatever system of vessels he filled, whether the whole vessels or each separately, he could not ascertain the direction and course of any particular vessel, nor its inosculations, but all was obscure, and as if constituting one chaotic mass. In wet preparations, however, he observed that the extreme branches of the hepatic artery opened into the vena portæ: that the branches of the vena portæ had a double termination; that some of them, by a sudden turn and serpentine course, terminated in the branches of the venæ cavæ hepaticæ †; while others were seen to terminate or open into the biliary ducts. Further he observed, that in all the branches of the vena portæ there was a peculiar compressed appearance which distinguished them from all the other vessels of the viscus.

* Soemmerring. Walther, loc. cit. &c.

† I should imagine that in this he might have been deceived by the lesser branches of the portæ (filled with injection) opening into the side of the larger trunks; and that there is no such terminaton of the hepatic arteries in the sides of the vena portarum, so that their open mouths are discernible.

Intersections of the intimate membrane of the liver, which divides and subdivides the fasciculi of vessels, have been observed. These are, however, somewhat obscure and indistinct. The last perceptible subdivisions of the substance of the liver have been called ACINI *; and they are rather presumed than directly proved to have in their composition an extreme ramification of the several vessels of which the liver consists. †

We have seen that Malpighi conceived that these bodies were simple glands collected on the ramifications of the vessels; that they were little vesicles; and that from them the pori bilarii took their origin. In this opinion he was successfully opposed by Ruysch, who affirmed that they were vascular; and in this opinion he has been supported by Albinus. It would, in truth, appear that the description of these partitions of the substance of the liver, and the ultimate subdivision of it into these little grains, about which there has been so much controversy, is not founded in an accurate observation, and that there are neither cryptæ, hollow and cellular, nor little bodies made up of convoluted arteries, but the minute parcels of vessels, which are collected together and united by fine cellular texture; they may be called acini, according to the definition which has been given in the introduction. ‡

* See the definition in the introduction to the anatomy of the viscera.

† Acinos nemo rejicit, ne Ruyschius quidem, sed de interiore fabrica disputatur. *Haller.*

‡ Finally, Ruysch's opinion may be given in these words (Epist. ad Virum Clar. Her. Boerhaave, p. 69.): "Sed nolo diutius tergiversari, fateor ergo, quod, quando primo incipiebam me exercere in anatomicis, videbam tunc quidem, quod in jecore humano se ostendebant acinuli parvi innumerabili numero, qui tum temporis appellabantur glandulæ; nam nemo cogitabat aliter sed manet sola jam hæc questio, an acinuli hi hic hærentes sint glandulæ simplicissimæ, folliculi cavi cum emissario an quid aliquid? dico nemo demonstravit illos tales esse ut hic assumis. Imo vero facile jam erit demonstrare, acinos hos cum criptis antea pertractis nihil commune habere: quia oculis nostris non apparent ut membranulæ cavæ et quia etiam non habent emissarium. Sed componuntur tantum ex extremitatibus ultimis vasculorum sanguiferorum unitis in formam spheræ rotunditatis, neque, quantum possum videre etiam membranula aliqua sua singulari circumambiuntur."

OF THE FUNCTION OF THE LIVER, AND OF THE SECRETION OF THE BILE.

Notwithstanding that the circumstance of the biliary duct being discovered points to one very obvious use of the liver, yet I am not satisfied that our knowledge of its functions is nearly perfect. In animal bodies one organ ministers to several functions. As the tongue is the organ of taste, of speech, of deglutition; as the lungs minister to respiration, to circulation, to speech, to smelling; as the skin serves many purposes; so I believe that we are too easily satisfied with discovering one use of the liver, in secreting the bile and stimulating the intestines.

The great size of this gland would impose upon us the belief that it serves some very important use in the animal economy, and the state of the system which originates with the disorder of the biliary secretion strengthens that belief. The function which it performs is probably the separation of some form of useless carbon; as M. Fourcroy has taught, that the bile is formed in a great measure of the combustible matter of the blood, thus making the liver a true auxiliary of the lungs.

Upon reviewing the whole system of the liver the peculiarities in the vena portæ strike us the most. It occurs to us that this great supply of blood to the liver, with the slow motion peculiar to venous blood, after having gone the circulation through the intestines, is a provision for the discharge of carbon and for the secretion of the bile. It is believed, that the secretion of bile is made from the blood of the vena portæ.

But as we see that this blood distributed by the branches of the vena portæ in the liver must be so far exhausted as to become incapable of all the uses accomplished by the arterial blood in other glands, we must look for another supply. We must be sensible, although the vena portæ be peculiarly adapted to secrete the bile, it is not capable of supplying nutrition and energy to the substance of the vessels of the liver, and that there

is therefore a necessity for arterial blood being sent to this gland through a branch of the arterial system. We have had occasion to remark, that no part retains its function in vigour, nor the living properties which belong to it, unless the arterial blood be circulated through it. Therefore it would appear necessary that the arteria hepatica, a branch of the aortic system, should be given to this viscus. This artery performs the same office here in the liver that the bronchial arteries do in the lungs, or the coronary arteries in the heart, or the vasa vasorum in the great vessels. The pulmonic artery carries venous blood into the lungs, which, having returned from the circulation of the body, cannot send off smaller branches to supply the membranes and vessels of the lungs; it is necessary that for this purpose branches of the aortic system shall enter the lungs. Again, in the heart the blood contained in its ventricles is incapable of supplying its substance; or the blood coming through the canals of the great vessels cannot be the means of ministering to the active powers of their coats: but for this purpose the vasa vasorum are distributed through the coats of the vessels. These vessels, therefore, bear an analogy to the arteria hepatica in the liver.

We must not, however, suppose that this scheme of the action of the vascular system of the liver, however rational and simple, will be universally allowed. Indeed there are circumstances which seem to stand in opposition to it. Of these the most interesting is the case of unusual distribution of the vessels of the liver communicated by Mr. Abernethy.

The subject was a female infant, which was supposed to be about ten months old. Among other varieties it was observed, that the branch of the cœliac artery distributed to the liver was larger than common, and exceeded by more than one third the usual size of the splenic artery. This was the only vessel which supplied the liver with blood for the purpose of either nutrition or secretion. The vena portarum was formed in the usual manner, but terminated in the inferior cava nearly on a line with the renal veins. The liver was of the usual size, but had not the usual inclination to the right

side of the body: it was situated in the middle of the upper part of the abdomen, and nearly an equal portion of the gland extended into either hypochondrium. The gall-bladder lay collapsed in its usual situation. It was of a natural structure, but rather smaller than common. On opening it there was found in it about half a tea-spoonful of bile. The bile in colour resembled that of children, being of a deep yellow brown, and tasted like bile, but it was not so acridly bitter and nauseating as common bile.

Mr. Abernethy remarks upon this case, that when an anatomist contemplates the performance of biliary secretion by a vein, a circumstance so contrary to the general economy of the body, he naturally concludes that bile cannot be prepared unless from venal blood; and he also infers, that the equal and undisturbed current of blood in the veins is favourable to the secretion; but that the circumstances of this case, in which bile was secreted by an artery, prove the fallacy of this reasoning.*

We may observe on this case, that it does not prove the bile to be, in the natural economy, secreted by the arteries and not by the vena portæ; for the artery here was unusually large, so that it performed a function in this instance which it does not usually perform. Had the artery been of the usual size, we might then have concluded that the vena portæ was distributed to the liver to serve some lesser use in the economy of the system, and that it did not secrete the bile.

The liver, it is said, was of the ordinary size. Now as the bulk of the liver is, in its natural state, made up of the dilated veins, it is some proof of what I should imagine had taken place here, that by some provision of the vessels, the arterial blood had been diffused, and the celerity of its motion checked previous to its ultimate distribution. Nay, it may have opened into the branches of veins answering to the extremities of the vena portæ.

In the deficiency of the acrid and bitter state of the

* See Mr. Abernethy's case, of uncommon formation of the liver. Phil. Transactions.

bile there is in this case evidence that the bile formed from the arterial blood is unlike the perfect secretion. I conceive this opinion to be countenanced by the peculiar circulation of the blood in the liver of the fœtus, and by its effects upon the secretion. We have seen in the fœtus, that almost the entire gland is supplied with arterial blood returning from the umbilical vein; and the natural deduction from this is, that this is the cause why the bile in the fœtus is of a less stimulating quality, and smaller in quantity, than in the adult.

I conclude, that this singular and interesting case* may strengthen the opinion which some have entertained, that the extreme branches of the hepatic artery pour blood into the extremities of the vena portæ previous to this formation of the bile by these veins; but it still leaves us with the general conclusion, that the peculiarities in the distribution of the vena portæ are a provision for the secretion of the bile, and that the branch of the aortic system, the hepatic artery, is otherwise necessary to the support of the function of the liver.

Finally, as to the use of the liver independently of the secretion of the bile, we must lay aside the opinions mentioned by Haller, that it supports the diaphragm, pushes it up in expiration, and receives the contraction of it equally in inspiration, so as uniformly to compress the other abdominal viscera; or that it foments and cherishes the stomach by the heat of its blood. These are at least as bad as the theories of the ancients mentioned in the beginning of this section. Haller sometimes puzzles us by the promiscuous admission of all facts and every kind of theory, with something of indecision in giving his own opinion.

There is another remark of Haller which deserves attention. "When I reflect," says he, "that there is no bile required in the fœtus, there being no food received; when, again, I see that the liver is of great size in the fœtus, and not small like the lungs, which are destined to an operation in the economy after birth, I cannot but

* I had a preparation, now in Edinburgh, where the liver wanted the hepatic artery.

suspect that it has some other use in the fœtus than the secretion of the bile." If the umbilical vein had opened directly into the cava, he thinks it would have returned with too great an impetus upon the heart, and would by its preponderancy have retarded the return of the blood from the lower extremities. He thinks that the liver is useful in breaking and weakening the impulse of the blood from the umbilical vein; that it is a guard to the right auricle, which would be otherwise endangered by the rapid flow of the blood. Now, surely the liver is much less able to stand the impulse of the blood than the heart; and yet there is no provision for the breaking of the force of the blood in the liver. Further, there is a direct duct of communication leading to the heart. There is no reason to believe that the umbilical vein carries back the blood with greater force than any other returning vein; on the contrary, from its size and the length of its course, it is natural to suppose the motion of the blood in it to be very slow and equable.

We must look upon the peculiarities in the circulation of the blood in the liver of the fœtus as a provision against the secretion of stimulating bile; for when the child is born and the circulation altered, bile is formed more abundantly, and becomes the stimulus to the whole abdominal viscera, rousing them to new action. As to the comparison which Haller has made between the state of the liver and that of the lungs, it is evident that the latter, though small in bulk, are fully formed, and want only inflation to complete their function. In the liver of the fœtus the vessels are distended with blood, to give them the size requisite for this future function; but that blood, either from its qualities or from the easy and direct passage it has into the heart, does not secrete the bile of a quality to stimulate the ducts and intestines, as in the adult circulation. If it did, we should not see the alimentary canal of the fœtus loaded with green matter, and the whole canal in a state of inactivity and torpor.

The natural bile of the adult system is of a deep yellow colour: when concentrated by the absorption

of its liquid parts it is brown: sometimes the bile of the gall-bladder is green, although there has been no disease in the liver. To compare it with something familiar, the bile is of the colour of wetted rhubarb. As to the use of the bile, the more common opinion is that it precipitates the feculent matter from the chylous fluid. But for this there is no other foundation than that such a separation does actually take place; but we have bestowed that action on the villous coat of the intestine, — with what show of reason may be seen above.

Mr. Hunter was of opinion that this bile did not incorporate with the chyle; it certainly does not confer on that fluid its sensible qualities, though it may be possible, according to the opinion of M. Fourcroy, that the alkaline and saline ingredients of the bile may combine with the chyle, while the albumen and resin may combine with the excrementitious matter.

If the bile was a mere excretion, if it were poured into the intestines merely to be thrown off, then the duct would have entered into the lower part of the gut, into the colon, and not into the duodenum.

Neither would we have observed that connection betwixt the state of digestion and the discharge of the bile into the intestine, which I have already noticed.

Perhaps we may conclude, that the liver linked in close sympathy with the intestines, connected by nerves, by blood-vessels, and by ducts, holds a control over their action by the stimulating fluid which it supplies to them.

OF THE PANCREAS.

The pancreas is a gland, the largest of those which have been called the conglomerated, that is, distinctly consisting of lesser parts united. It is of a long form like a dog's tongue, and lies across the spine, and behind the stomach. Its excretory duct opens into the duodenum.

The pancreas is confined betwixt the two laminæ of

the mesocolon, and it is united to them by a loose cellular membrane; it lies before the great mesenteric vessels, with its posterior face upon the spine and aorta, and covered anteriorly by the superior lamina of the mesocolon. It is divided into the head, body, and extremity. The head is towards the right side: its small extremity touches the spleen, and is near the capsule of the left kidney; but towards the right extremity it increases gradually in massiness, until its head lodges upon the duodenum. It is like the salivary glands in its appearance, consisting of lobules successively smaller and smaller; and it also resembles them in the manner in which its duct is formed. The duct * begins towards the left extremity by exceedingly small branches: these running together form a middle duct, which taking a serpentine course towards the great extremity, and increased by the accession of the lateral branches in its course, becomes nearly of the size of a writing quill. Towards the right, the head of the pancreas is irregular, and indeed a lesser pancreas generally projects from it. Approaching the duodenum the duct unites to the biliary duct, and opens along with it into the duodenum. A valve has been described as in the extremity of the pancreatic duct, but it is certainly incapable of the action of a valve, as the bile has been found to have gone retrograde into the trunk of the pancreatic duct. Sometimes there are two pancreatic ducts, but more frequently the part of the gland next the duodenum, and which is called the round head of the pancreas, has an excretory duct peculiar to itself, which either opens into the duodenum separately from the main duct, by piercing the coats of the intestines nearer the stomach, or sometimes opens further down. In the dog there are distinctly two ducts, the one opening into the biliary duct, the other separately into the duodenum.

De Graaff, Ruysch, and many others have made experiments to discover the nature of the secretion from the pancreas. Tubes were introduced into the ducts, and bottles were appended to them in living dogs, so

* Ductus Virsungi.

as to catch the pancreatic fluid: it was found ropy, insipid, and like the saliva. It has therefore been concluded, from the colour, structure, ducts, and secretion of the pancreas having so strict a resemblance to those of the parotid and submaxillary glands, that it is of the nature of the salivary glands of the mouth. The general opinion has been, that it is useful in secreting a fluid which dilutes and moderates the acrimony of the bile. More accurate chymical examination of the pancreatic fluid has not been made, or has not been successful in showing any peculiarity in it.

Considering the pancreas as a salivary gland, how great must be the quantity of fluid poured out by it, if, as we are entitled to do, we take the analogy of the parotid, submaxillary, and sublingual glands! These salivary glands, although they may be said to surround all the jaws from the zygomatic process on either side, are nothing in massiness and size to the pancreas. Again, the pancreas is most plentifully supplied with blood-vessels. Besides lesser branches of arteries, the pancreatico-duodenalis gives two branches, which take an extensive course through it, and are joined by other mesenteric twigs; and twigs proceed from the vessels of the stomach, and even from the hepatic artery; but more particularly we have to observe the large branches bestowed upon it by the splenic artery, where it takes its course close upon it.

While the masticators are working, the parotid gland pours out so great a quantity of saliva, says M. Helvetius, that it is inconceivable, and what I should not believe, had I not seen it in a soldier of the guards. A cut with a sabre in the cheek had opened the salivary duct: the wound healing on the inside of the cheek left a fistulous discharge from the parotid duct. When he ate, there flowed from this hole a great abundance of saliva: so that during dinner, which is not long in the Hôtel Dieu, it moistened several napkins. How much must flow from all the salivary glands! how much from the pancreas, which is greater than them all collectively!

The pancreas being supplied with arteries from the

splenic artery and duodenal artery, it must partake of the increased circulation of blood, while this system of vessels is excited by the fulness of the stomach. By this it must be prepared with an increase of secretion proportioned to the food passing the pylorus.

It is probable that the contents of the stomach when passing the duodenum, or the bile flowing from the biliary ducts, become the stimulus to the discharge of the pancreatic fluid; and as we see that the morsel in the mouth will quickly produce an almost instantaneous secretion and discharge of saliva, so we are led to conclude that the flow of pancreatic fluid may be as suddenly produced without the necessity of a reservoir, as in the biliary system. We naturally conceive that the effect of this fluid is to diminish the viscidity of the bile, and by diluting it, to mix it uniformly with the food. There are, however, few facts to enable us to reason on the effects of the pancreatic fluid. If we give full credit to the experiments of Malpighi and Brunner, we may conclude, that when the pancreas is taken away, the more acrid bile causes vomiting or voracious appetite by its stimulus. Scirrhus of the pancreas has been found attended with a costive and slow motion of the intestines; which seems to contradict the result of these experiments on animals: but by the scirrhosity and enlargement of the pancreas the biliary ducts may have been more or less compressed, and the retardation of the usual quantity of the biliary secretion might produce the slowness of the bowels.*

* According to the hypothesis of Silvius, the use of the pancreas was to supply an acrid spirit or juice; and the biliary secretion being of the nature of an alkali, these two struggling together caused the separation of the chyle from the fæces. The struggle did not stop here, but these enemies being carried into the blood, continued their warfare in the heart itself, and lighted up the vital flame there.

Nay, if we believe the experiment of F. Schuyl (de Veteri Med.), this hypothesis was not without its proofs; for having tied in the portion of the duodenum of a living dog, where the pancreatic and biliary ducts enter, he saw the ebullition from the struggle of the acid and the alkali; and when he compressed the hepatic duct, the tumefaction of the intestine subsided; when he took off this compression, it was again blown up. As this experiment has not succeeded since, as Haller observes, Schuyl was probably deceived by the peristaltic motion of the intestines.

On the whole, I am inclined to think that the pancreas is a gland of dilution merely, that the flow of its secretion will depend on the state of the food or of the bile passing the duodenum. That, as in drinking, the saliva is not excited to flow, neither is the pancreatic fluid, when the matters descending through the duodenum are bland and liquid, but when they require dilution this gland is ready to afford it.

OF THE SPLEEN.

The spleen is a viscus of an irregular, oval figure, and dark purple colour. It is attached to the great extremity of the stomach. It is soft in its substance; and has the peritoneal coat very delicate. We should be glad could we say, with the old anatomists, that it is of a parenchymatous structure, for in truth little is known of its organization.

In treating of this subject we must be indulged in some speculation; and, indeed, it is privileged ground; for the history of the opinions regarding the supposed function of the spleen is full of loose conjectures or wild hypotheses, and nothing is as yet certainly known of its use.

SEAT AND CONNECTIONS.

The spleen is seated in the left hypochondrium; above the left kidney; and under the protection of the false ribs; and of course it is under the edge of the diaphragm. It is connected with the stomach by the cellular membrane, by the omentum, and in a still more particular manner by the vasa brevia. It has also connections with the left extremity of the pancreas by cellular membrane, and the branches of the splenic vessels. Lastly, it has a firmer attachment to the

diaphragm, by means of a ligament formed by the peritonæum.*

The spleen is of an irregular figure. Where it is contiguous to the diaphragm it is uniformly convex: towards the stomach its surface, while it is hollowed out and concave, presents two sides, so that we say the whole mass is somewhat of a triangular form. The anterior edge of the spleen is notched with deep sulci; behind, and at the upper part, the margin is large and round.

The substance of the spleen is the most spongy, tender, and soft of all the abdominal viscera; so much so, that not only does the finger make an impression upon its surface, but it actually disorders and tears its vessels. After a successful injection the whole seems made up of vessels; and if any thing like acini or globules are to be observed, the microscope will show them to be accidentally produced by the fasciculi of vessels. By injecting the vessels of the spleen with wax, and corroding it, granules of wax are seen on the extremities of the veins as if they had filled cells; and when blown up, dried and cut, the cells appear to be continuous and regular. The cellular texture, uniting the vessels of the spleen, assume a remarkably stellated appearance. Upon the whole, this viscus has a resemblance to the substance of the placenta. The spleen is seldom smaller than natural; often greatly enlarged.† I have seen it equal to the liver in size, and filling the whole left side of the belly. It has been frequently found thus enlarged, without any peculiar symptoms indicating such a disease during life. From its soft texture and great vascularity, like the liver, it has been found rent

* Yet the spleen is very apt to change its situation, or to fall down from under the protection of the false ribs. It is liable to enlargement. From which circumstances it will not be wonderful if it is wounded in tapping for the ascites. See Monro on Dropsy. Lienis a statu suo deviationes, Sandifort, Thesaur. vol. iii. L. Baader observationes variæ. Albinus Acad. Annot. lib. vii. cap. xiv.

† For varieties in size and form, see Morgagni Advers. III. Animad. XIX.

by blows and falls *; and wounds here, as in the liver, by opening the large vessels are suddenly fatal. Sometimes it is hard and scirrhous: it is subject to inflammation, to ossification, and to have tubercles formed in its substance. There is seldom suppuration in it. The spleen has been observed to swell up and enlarge when the stomach is empty, and to be contracted when it is full. It has been observed, that it is large and spongy in those who have died a lingering death, or who have been long ailing; that, on the contrary, it is smaller and firm in those who have died suddenly a violent death.

We are informed, that the blood of the splenic vein is peculiar, insomuch that it does not coagulate like the blood in the other veins of the body. †

That which, more than any other circumstance, excites our attention, is the great size of the blood-vessels of the spleen. Both the splenic vein and the artery are of great size in proportion to the bulk and weight of the spleen; and in their course they are particularly tortuous. I conceive we may also draw consequences from the distribution of their branches to the stomach (viz. the vasa brevia and left gastro-epiploic) and to the pancreas. Its lymphatics are numerous. It is supplied with nerves, but has very little common sensibility. It has no excretory duct.

Professor Coleman made experiments on dogs, and found that when they were deprived of the spleen, they became fat and indolent. An old pupil has lately given me an account of his cutting off the spleen in a native of South America. The spleen, escaping from a wound, had become gangrenous. He could observe no effect to result from this extirpation.

Opinions regarding the use of the spleen. —

* I have seen death from rupture of the spleen, by a wound which never penetrated the abdomen: a pistol shot entered the chest and struck the diaphragm without piercing it; the lad died with effusion in the belly; and, on examination, the spleen was found burst by the contusion.

† With regard to this point I have no opinion, having hitherto neglected to examine the fact. The experiments of Sir Everard Home countenance the opinion.

Of the various uses of the spleen, the lowest conjecture, in respect to ingenuity or probability, is, that like a sand-bath, it foments the stomach, and promotes the process of digestion. This notion is, perhaps, not inferior in absurdity to that opinion, which ascribed to the spleen the office of forming an acid juice, which, being carried by the vasa brevia into the stomach, was supposed to excite the appetite.*

It was a better conception that the spleen is the seat of melancholy; "that moping here doth hypochondria sit:" or of "laughter holding both his sides,"—of which the holding of the sides was the evidence. And again, since tickling the ribs is a demonstration of the effect from this excitement of the spleen †, that the growth of the spleen promotes laughter to such a degree, that it becomes a permanent silly simper. Nay, further, we have authority for the excision of the spleen from those who are otherwise incurable in their propensity to laughter, an operation which promises certain success!

The following is a theory which has been very commonly received. A great quantity of blood is imported into the spleen with a slow motion, owing to the serpentine course of the vessels. When the stomach is empty, the blood is received in a greater quantity by the spleen, where it has an opportunity of stagnating. Here the blood, fomented, attenuated, and in a manner dissolved by the neighbourhood of the putrid fæces in the colon, enters upon the first stage of putrefaction. By this resolving of the blood it is made more fluid, in which state it is returned by the veins, there being no excretory

* I am mistaken in calling this the lowest in absurdity. The spleen has been considered as the seat of the soul! the cause of venereal appetite! the gland which formed the mucilaginous fluids of the joints! The atrabilis was received here, concocted and transmitted to the liver. It drew forth and formed blood from the stomach, &c. Other physiologists, not contented with the theories presented to them, and yet incapable of suggesting others more likely, have very modestly asserted that the spleen was of no use at all.

† "Risus in liene sedes videtur ex effectu titilationis natque in plurimis mortalibus risum excitat," &c. Haller. His sober objection is, that tickling the right side will do as well as the left.

ducts. Now when the spleen is compressed between the distended stomach and the ribs, and the contracting diaphragm, the blood is pressed out from it in greater quantity and celerity towards the liver, mixing with the sluggish blood in the trunk of the vena portæ; replenished with the fat and oil of the omentum, it dilates that vessel, and prevents the stagnation and congelation of the blood. In short, the spleen has been supposed to be subservient to the function of the liver, and to the preparation of a watery (and sub-alkaline) fluid to the blood of the portæ, all which is unfounded conjecture merely.

Another opinion has been, that it counterbalanced the mass of the liver seated to the right side of the belly.

Hewson entertained a theory regarding the use of the spleen, which is injurious to his reputation. He conceived that the spleen added the flat vesicle of the globules of the blood: his only observation in way of proof was, that he saw a few red globules returning by the lymphatics of the spleen: the effect, I have no doubt, of the injury of its substance, or of the compression of its vessels. It seems to me strange that such a man, seeing the large splenic artery throwing its full tide of perfect arterial blood into the spleen, full of globules, complete in every respect, and again seeing a few globules carried back by the lymphatics, should imagine that this artery formed these few vesicles, with which it was already so fully charged.

That the stomach, duodenum, liver, pancreas, and spleen, are united in function, I have no doubt. Nature has placed them, not only in juxta-position, but has united them by the same entanglement of nerves, and has given them the same system of vessels. The cœliac trunk supplies them all.

Further, I conceive the spleen to be an organ subservient to the stomach; and not only the constant attachment of it to the stomach in the human body, but the frequency of its attachment to the stomach in the lower animals, confirms the opinion. I regard it as a provision for giving the vessels of the stomach an occasional

power and greater activity, enabling them to pour out a quantity of fluid proportioned to the necessity of the digestion. In the first place, let us examine the course and form of the splenic artery, and I think we shall find the great peculiarity of its size, and tortuous form, and strong coats, a provision for occasional great increase of power; while, if not roused by the peculiar sympathies which actuate it, it is of a form to retard and weaken the velocity of the blood. This is founded on these propositions: —

1. The muscular power of an artery increases as it recedes from the heart; the elastic power diminishes.

2. An artery, the nearer it approaches to its final distribution, is the more immediately under the excitement and control of the organ; is active when the organ is excited; is, relatively speaking, quiescent when that organ is not called by its sympathies to exercise its function.

3. An artery tortuous in its course has more muscularity and greater power of action than one which takes a straight course; but in proportion to the increase of power which it obtains by its increase of length in this tortuous and bending course, will these turns retard and weaken the force of the heart upon the extreme ramifications of the vessel.

Thus a tortuous artery is the means of increasing the velocity of the blood by its own action, but it makes the organ less dependent on the general force of the circulation. We accordingly find, that in those organs where there is occasional activity alternating with a quiescent state, the artery is tortuous; and where there is an increase of force required in the circulation, there the artery, from being straight in its course, becomes crooked and twisted in every way. *

* This has been supposed to be the effect of the impulse of the blood; but nothing can be more false. Let any one examine the artery of a limb when a great tumour is growing; the artery will be found tortuous to supply it. Again, in the aneurismal varix, where there is a breach in the artery, and the blood finds a freer return to the heart, the artery will be found enlarged and tortuous in order to supply the lower part of the limb; while there is a quantity of the blood withdrawn from the circulation by the communication with the vein.

From these remarks, we may be inclined to draw, from the tortuous figure of the splenic artery, a conclusion somewhat different from that which has hitherto been deduced. We may conclude, that it is not the means of retarding the blood in its circulation, but of giving force to it. The splenic artery does not only ramify in the spleen, but it supplies all the left part of the stomach, and that great sacculated extremity in particular which receives the food, and in which the process of digestion is chiefly performed. My idea is, that when the stomach is empty, when there is no food in it to solicit the discharge of the gastric fluid, the blood circulates in a moderate degree in the coats of the stomach, and the spleen receives the surcharge of blood; but when a full meal is taken into the stomach, when the action of the gastric juice is required in great quantity, the action of the splenic artery is solicited to the vasa brevia and left gastro-epiploic artery, and thus a sudden flow of the gastric fluid is bestowed by the increased activity of the splenic artery. When, again, the contents of the stomach are fully saturated with the fluids from its coats, there is no longer an excited action of the splenic vessels, and the artery terminating in the veins, the spleen returns the blood to the liver. While the vessels of the stomach partake largely of the supply of blood, the arteries to the pancreas also receive some increase of activity; and the blood of the vena portæ requires an additional supply and activity.

I leave this opinion of the vascular system of the spleen, as expressed in former editions, and with the conviction that I have assigned one use of the splenic vessels, and afforded an explanation of their tortuous form; but these remarks do not explain the structure of the body of the spleen.

That there are cells in the spleen is very generally believed, and that some operation, connected with the economy, is performed there, is also a general belief. Sir Everard Home was of opinion, at one time, that the spleen drew the fluids from the stomach, and delivered them into the circulation. But finding that infusions of rhubarb got into the circulation from the stomach when

the pyloric orifice was tied, and the spleen taken away from the animal, he gave up that opinion. But he has made experiments which lead to the belief that a secretion is poured into the cells of the spleen; but for what purpose there are these cells or this secretion is still conjecture.

The probability is, and it amounts to no more, that the venous blood of the spleen is useful in the function of the liver. Either it may supply venous blood in proportion to the wants of the liver, or in that venous blood carried to the liver there may be some peculiar change wrought by the spleen, and fitting it for the secretion of bile.

OF THE URINARY ORGANS.

OF THE KIDNEY.

Under the head of urinary organs, we enumerate the kidneys, ureters, bladder, and urethra. The kidneys are distinct from those parts which have hitherto engaged us, as they secrete the urine, and form therefore the link betwixt the viscera of the abdomen and those of the pelvis; for though lying in the abdomen, they are more strictly connected with the parts in the pelvis. The structure of the kidney forms a very interesting subject of enquiry; because it is the field of dispute betwixt the contending parties regarding the structure of glands and the theory of secretion. It is chiefly from the kidneys that the facts are drawn in illustration of the opinions of Malpighi, Ruysch, and all the others.

Form, seat, and connections.—The kidneys lie on each side of the spine, and betwixt the spine of the ilium and the lowest ribs. It is sunk, as it were, in the fat of the loins, and by that means attached to muscles of the loins; it rests in part on the lower part of the diaphragm; which last connection is the cause of the pain felt in respiration during inflammation in the kidney. The right kidney is placed somewhat lower than the left, which is owing to the greater size of the liver on that side.

The kidneys are without the abdomen, that is to say, behind the peritonæum, as shown above; for the kidney lying close upon the muscles of the loins, the peritonæum is merely stretched over it. This is the reason why calculi in the kidney have wrought themselves out by fistulæ in the loins; and it is the ground of the hazardous, indeed absurd, proposal of cutting into the kidney to extract calculi.*

The adipose membrane surrounds the kidney, and forms a kind of capsule; for it is this which is sometimes in an extraordinary degree loaded with accumulated fat. Upon this capsule the cæcum is attached on the right side, and a turn of the colon on the left, and betwixt the kidneys and the intestines there is a sympathy, which is apparent in the nephritic colic. The proper coat of the kidney is fine, dense, and firm, and closely surrounds the proper structure of the gland.

The figure of the kidney is an oval, a little incurvated, so as to form a sulcus or general concavity to one side, while the other takes a greater convexity. By the concave surface of the kidney, which is towards the spine and great vessels, the arteries and veins and ureter pass in by the sinus, round which the substance or glandular body of the kidney terminates abruptly.

The abdominal aorta and the vena cava lying close on the spine and near to each other, give off laterally the emulgent arteries and veins. The renal or emulgent artery comes from the side of the aorta betwixt the upper and the lower mesenteric arteries; that of the left kidney has its origin a little higher than the right: and the aorta being on the left and the cava towards the right side of the spine, the left emulgent artery is shorter than the vein; the artery longer than the vein on the right side. Again, the aorta being more closely attached to the spine, the emulgent vein lies rather above the artery.†

* See a case, by Dr. Simmons in the Philosophical Transactions, vol. lxiv.

† The vessels of the kidney vary more than those of any other viscus. C. H. Meuder de urinæ excretione. Sandifort, Thes. viii.— Albinus. Acad. Annot. b. vii. c. 11.

The vessels, and especially the arteries of the kidney, are very irregular in their number and form. Where they enter the body of the gland, they are accompanied with a capsule which continues with them to their final distribution. Sometimes a solitary vein is seen making its exit by the convex surface of the kidney.

We have had occasion to remark on the nerves of the kidneys and their connection with the coverings of the testicle, and to notice their effect in producing numbness of the thigh and retraction of the scrotum in inflammation of the gland, when stones lodge in the pelvis or ureter.

Upon the subject of the sensibility of the kidney, however, we must be aware that disease, inflammation, suppuration, nay, even total wasting of the kidney may take place without any indication from pain, and certainly without pain referable to the part itself.

The excretory duct of the kidney is called URETER: it leads from the kidney to the urinary bladder. When we trace it backwards into the kidney it is found to enter the sinus of the kidney. Here it is enlarged into a considerable sac, which is called the PELVIS of the kidney. This is a kind of reservoir, which, lying partly in the embrace of the solid and glandular substance of the kidney, sends up several prolongations like the fingers of a glove. These are called *infundibula*. They are, indeed, like funnels, for they expand to receive the papillæ of the kidney from which the urine distils.

It may be observed, however, that the term pelvis is taken from the greater dilatation of the ureter within the gland, which is seen in brutes; and that in man it is not so remarkable, the ureter branching with only a lesser degree of the sacculated form into three or four divisions, and these into the infundibula.*

The coats of the ureter are three in number;—a dense outer coat; a middle coat, apparently consisting of circular muscular fibres, though this has been denied; and a smooth inner coat (very improperly called villous),

* In my Collection, specimens may be seen of the pelvis in the human kidney dilated, to contain several ounces.

which secretes a mucus to defend it from the acrimony of the urine. The ureters do not run in a direct course to the bladder of urine: they are in some places irregularly dilated, as when they pass over the psoas muscle *; dropping deep into the pelvis, and getting betwixt the rectum and bladder, they open obliquely into the latter. † The use of the ureter is to conduct the urine which is incessantly secreted ‡ in the kidney to the urinary bladder, where it can be retained and discharged at a convenient time.

MINUTE STRUCTURE OF THE KIDNEY.

Let us now attend to the structure of the gland. The ancients, says Malpighi, contented themselves with the idea of a sieve, as conveying a knowledge of the manner in which the urine was drawn off by the kidney; that the fibres of its parenchymatous matter attracted the serum of the blood; that the fibrous matter was perforated with innumerable foramina; or that the whole was a congeries of canals through which the urine was strained and drawn off. Malpighi set himself to refute these vague opinions by the minute examination of the structure of the kidney; and he seems to have known almost all that we now know. Though we do not acquiesce in his opinions regarding the final and minute structure, he describes accurately every part of the gland.

In the first place, when we examine the outward appearance of the kidney of the fœtus, we observe that it is not, like that of the adult, smooth and uniform, but tu-

* When the bladder is contracted in consequence of a stone, or when it is dilated by obstructions, as from stricture, the ureters become dilated to the size of small intestines. Specimens may be seen in the Collection.

† *Nuck* describes the ureters as being very irregular, and always contracted in three or four places. *Bartholin* thought he observed valves as the duct enters the bladder, and *Coschwitz* describes valves in their course.

‡ When a fistula of the loins communicates with the kidney the urine flows uninterruptedly.

berculated or lobulated; that it consists of distinct parts, or glands united together. Again, when we examine the kidneys of other animals, we find in several instances that the full-grown animal retains this lobulated form. In short, it immediately strikes us, that the kidney is not a uniform mass of glandular matter, but that it most resembles those glands which they call conglomerate, and which consist of several compartments or distinct glands united together.*

A section of the kidney shows us these parts. First, we see towards the surface that which is called the cortical or glandular part. Secondly, striæ, converging towards the centre of the kidney, being what is called the tubular part of the kidney.† These tubuli are divided into fasciculi, taking a conical shape; and these converging unite at the apex; two or three of them united form a papilla. The papillæ are generally ten or twelve in number, or even more, in each kidney; their points are received into the extremity of the infundibula; they pour the urine into these tubes, which is collected in the pelvis or cavity leading to the ureters.

We shall now separate one of those compartments of the kidney, which correspond with the original lobulated form of the gland. This figure represents such a portion.

When we examine one of these papillæ in a lobulated kidney, we find that it is the centre of one of these subdivisions.‡

The papilla C is merely the continuation of the tubuli B; but it is that part which projects from the body

* The figure represents the kidney of the fœtus, which is *lobulated*, and the *glandula renalis* seated upon it.

† Improperly medullary, sometimes STRIATA. Winslow (*traité du Basventre*) has these distinctions of the substance of the kidney:—1. Corticale; 2. Cannellé sillonné, ou tubuleuse; 3. Mammelonnée.

‡ A. A. Cortical substance; B. Tubular part; C. Papilla; D. Ducts.

of the kidney into the calyx or infundibulum; and although these divisions of the substance of the kidney are enumerated as three distinct parts, the cortical, tubular, and mamillary parts, they are properly only two, the cortical and tubular parts.

Some, however, have made a new distinction, by asserting that a vascular part is to be observed betwixt the cortical and tubular, or striated parts; but it is not the case; for although when we make a regular section of the whole gland, the mouths of some larger vessels may be observed betwixt the fasciculi of the urinary tubes, yet they are irregular ramifications tending to the outer cortical part, and not such as separate the tubular and cortical part from each other, nor so regular as to be considered as one of the subdivisions of the kidney.

OF THE CORTICAL PART.

The external and cortical part of the kidney is by all allowed to be the secreting, or, as they rather term it, the secerning part of the organ. It was this part which the older writers considered as in a more particular manner to consist of a peculiar fleshy substance, or parenchymatous matter. It is in this cortical matter that the glandular bodies described by Malpighi are supposed to be seated: they are called *corpora globosa*, or *rotunda*. They are to be seen very distinctly in many brutes; for example, in the horse's and cow's kidney. But he asserted these bodies to be also observable in the human kidney; to demonstrate which he injected a black liquid mixed with spirit of wine, by which the kidney becoming universally tinged, you may then see, he said, when you have torn off the coats of the kidney, small glands partaking of the colour of the arteries. These are the glands of the cortical part of the kidney, which Malpighi described as hanging upon the branches of the arteries like fruit upon the pendant branches, and round which the arteries and veins are ramified and

convoluted, like delicate tendrils, so as to give them the dark colour which they have.

Into these bodies he supposed the urine to be secreted, and that from these bodies it was conveyed into the uriniferous ducts or tubular part of the kidney; but he acknowledges that the communication betwixt the ducts and glands is very obscure.

Ruysch and Vieussens held a very opposite opinion regarding the structure of the kidney.* Ruysch, by throwing his injections into the renal arteries, found that he filled the urinary tubes, the ducts of Bellini, and the pelvis itself. Hence he conjectured that the tubuli uriniferi, or excretory ducts of the kidney, were the continued branches of the renal artery, without the intervention of any glandular apparatus.†

Ruysch did not neglect the examination of the little bodies which are to be seen in the cortical substance. He did not, however, allow they were glands, but confidently asserted that they were merely the convoluted arteries which were formed into these contorted bundles before finally stretching out, and terminating in the straight urinary tubes.‡

When, after minute injection of the kidney, we make a section of its whole substance, we see vessels emerging from the more confused intricate vascularity of the cortical part, and running inward in striæ towards the papillæ: what we see there, are, in my conception, chiefly veins. And this I conclude, both from the result of injections, and from knowing that the veins are in general numerous surrounding the excretory ducts; besides, they retain the blood in them like the veins. These vessels running in straight lines, and converging towards the papillæ are not the tubuli uriniferi, but the

* Ruysch and Vieussens long contended for the claim of the discovery of the continuation of the arteries of the kidney into the urinary ducts. Ruysch at first acquiesced in the opinion of Malpighi, as we have said.

† Thes. Anat. ii. p. 31.

‡ In the epist. to Boerhaave, p. 77., we find Ruysch speaking much more modestly: "In rene humano rotunda corpuscula esse, fateor, sed sunt tam exilia, ut nihil possim definire de illis. Adeoque non licet magis dicere quod sint glandulæ, quam aliud quid."

blood-vessels accompanying them, the tubes themselves being transparent.

Yet I imagine it was by these vessels that Ruysch was deceived; for tracing them from the extreme arteries, and seeing them suddenly altered in their form and direction, and running towards the papillæ, he imagined them to be the excretory ducts continued from the extreme branches of the arteries.

Winslow supposes the corpuscles, which are seen in the cortical part of the kidney, to be the extremities of the cut tubuli, filled either with blood or with a coloured injection. But this they evidently are not; for by making the substance around them transparent, they are seen within the surface, and they are little grains, not the extremity of tubes, nor extended in lines.

Boerhaave, although he saw in the preparations of Ruysch the injection passed into the uriniferous tubes, yet in the main favoured the opinions of Malpighi; and having sometimes observed these tubes filled with injections, while at intervals they were transparent or pale, and contained only a watery fluid, he ventured to conclude that there was a double operation going forward in the kidney; that the pale watery urine was quickly drawn off by the continuous tubes; but that the urine of the other quality and higher colour was separated by a more perfect and slower secretion through the glandular bodies.

In the history of opinions, to Boerhaave succeeds Bertin, who writes a long and laboured paper in the Memoirs of the Academy of Sciences for 1744: upon the whole, he may be considered as endeavouring to prove by dissection what was rather an hypothesis with Boerhaave. Bertin describes glands in the substance of the kidney; but these he is careful to distinguish from the corpuscles of Malpighi, which he also conceives to be the extremities of vessels merely.

He observes, that there are to be seen serpentine vessels, such as Ruysch described*; which, arising at

* Mesches de M. Winslow, ou vassieaux spongieuses de Vieussens, ou tuyaux serpentins de Ruysch.

the circumference of the cortical substance, are reflected inward in a tortuous form, and which, at last, approaching the tubular part, terminate in straight tubes, or are continued into the tubuli uriniferi.

But betwixt the meshes of vessels which are described, and which terminate in the tubuli, there are beds of glands; which acervulæ of small glandular bodies are, as it were, laid in a tract from the circumference towards the centre, and appear to terminate or to be connected with the tubuli uriniferi as the arteries are.

M. Ferrein has opposed all these opinions in a paper in the Memoirs of the Academy of Sciences for 1749. He asserts that the body of the kidney is neither composed of glands nor a congeries of blood-vessels; that it is a peculiar substance, which when examined is found to consist of transparent vessels. These, he says, are wonderfully convoluted in the cortical part of the kidney, so as to resemble glands, and stretch in parallel lines towards the papillæ, where they form what is called the tubuli uriniferi. Amongst these transparent tubes the blood-vessels ramify to great minuteness, and accompany them where they are reflected directly inward to form the tubuli. Much ridicule, he observes, has been thrown upon the term parenchyma of the ancients; but notwithstanding, he affirms, that there is in all glands a substance dissimilar from the blood-vessels, a gelatinous-like matter, which consists of or contains these pellucid tubuli.

Tubular part. — The term here used is universally received; and all seem agreed that the striæ converging to the centre of the kidney, and taking a pyramidal shape, are the excretory ducts. We have seen that they were supposed by some anatomists to be formed by the continuation of the extreme branches of the arteries; but this opinion we shall venture to say arose from the appearance of the blood-vessels injected, which lie parallel and close to them. They are evidently transparent tubes, and probably the fibrous appearance of the whole pyramidal body formed by them is owing to the accompanying blood-vessels. These lesser ducts, as they approach the papillæ, terminate in larger ducts, which

finally open into the ducts of Bellini at the point of the papillæ. The papillæ we have seen to be that part of the pyramidal body which projects into the calyces or infundibula, and from their point little drops may be perceived to form when they are compressed. This fluid comes from the ducts of Bellini.

I have detailed the several opinions regarding the structure of the kidney; and neither do I wish here to vamp up an opinion from the aggregate of these contradictory reports, nor have I been able to draw a decided conclusion from my own experience. I must however conclude, there yet remains much to be done in investigating the minute structure of the glandular viscera. *

OFFICE OF THE KIDNEYS.

The kidneys secrete the urine: but this drawing off of the fluid from the system is not the sole object of the secretion; the water conveys away certain matters in solution. As the urine contains more saline matter than any other secretion, we are led to suppose, that the kidney is of use to rid the system of these saline substances.

These principally consist of the muriatic salts, as the muriate of potash and soda; the phosphoric salts, as phosphate of soda, of lime, and ammonia; the phosphoric and lithic acids, with animal extractive matter, and a gelatinous or albuminous matter. In short, chymists have declared, that eleven substances are constantly present in the urine, and occasionally others, the product of morbid action; so that from the kidneys much, both of the solid and fluid composition of the frame, must be sent off in that circle of action, deposition, and absorption, by which both the structure of the frame and the qualities of the living body are preserved.

* Of the kidney, much in Morgagni, Adversar. Anatom. iii.

OF THE CAPSULÆ RENALES.*

The renal capsules are glandular bodies of a reddish yellow colour, one attached to each kidney. The gland is seated like a cap on the upper end of the kidney. It is of a form like an irregular crescent, and suited to the shape of that part of the kidney to which it is attached; at the same time that it has three acute edges, being something of a triangular form. — The upper edge has been called crista, while the lower edges have the name of lobes. It is in the fœtus and in childhood that the renal capsule is large and perfect; in the adult it has shrunk, and no longer bears the same relative size to the kidney. In the fœtus the renal capsule is as large as the kidney, and the capsules of each side are continued into each other, being stretched across the aorta and vena cava.†

The vessels sent to this body are somewhat irregular; they come from the renal or emulgent arteries and veins, from the cœliac artery or phrenic, or from the trunk of the aorta, and even from the lumbar arteries.

By separating the lobes of this body we find something like a cavity, which has been roundly asserted by some to be a regular ventricle; by others altogether denied. Finding a cavity, they supposed they must discover the excretory duct. Some conceive that it must be connected with the pelvis of the kidney; some, with the thoracic duct; some, with the testicle; but every thing relating to the use of this body has hitherto eluded research, and all is doubt and uncertain speculation.‡ For my own part, I conceive that this body is useful in the fœtus, by deriving the blood from the kidney, that gland not then having undertaken its proper office of secreting the urine.

* *Glandulæ atrobilaræ, renes succenturiatæ, glandulæ renales,* &c. See the marginal figure.

† For various authorities on the size and appearance of this body, see Morgagni, Epist. Anatom. xx.

‡ Morgagni, Adversar. An. iii. A. xxxii. 329. Valsalva is reduced to the necessity of quoting Scripture, and Morgagni is as much at a loss, Epist. Anat. xx., being obliged to join in the words of Eustachius: "iis relinquamus, qui anatomen accuratius exercent, inquirendum." — *Morgagni*, loc. cit.

THE

ANATOMY

OF THE

VISCERA OF THE PELVIS.

THE

ANATOMY

OF THE

MALE PARTS OF GENERATION.

As there is no very accurate division betwixt the viscera of the abdomen and those of the pelvis; as the uterus and bladder, being viscera of the pelvis, rise into the belly when distended, and are in every respect like the abdominal viscera, many have altogether objected to a division of the viscera of the abdomen and pelvis: nevertheless, there appears to be good reason for this division of the subject. The functions of the parts are different; the manner of their connection is different, and their diseases have widely different effects.

We have seen that the pelvis consists of the sacrum, os coccygis, and ossa innominata, and that anatomists have distinguished the true and the false pelvis. The false pelvis is formed of the extended wings of the ossa ilii, and supports the viscera of the abdomen. The true pelvis consists of that cavity which is beneath the promontory of the sacrum and the linea innominata; it contains, in man, the rectum, the urinary bladder, the prostate gland, the vesiculæ seminales, and part of the urethra. In woman it contains the rectum, vagina, uterus, Fallopian tubes, ligaments of the uterus, and ovaria.

The manner in which the parts of the male pelvis are connected, and the anatomy of the urinary bladder, prostate gland, and urethra, will form the subject of

the first section; while the anatomy of the parts connected in function with those of the pelvis, but seated without, will form the subject of the second.

OF THE PARTS WITHIN THE PELVIS.

We have seen that the abdominal viscera are involved in a common membrane; that this membrane is uniformly smooth; and that it has a secretion on its surface which bedews the whole, and allows the parts an easy shifting motion on each other. The parts in the pelvis must also have motion, but they are at the same time more intimately connected; a loose cellular membrane is the medium of adhesion here: the parts are imbedded in cellular membrane, which is interwoven with muscular fibres towards the lower opening of the pelvis, and further braced by the levator ani and muscles of the perinæum. This gives to the whole due support; enabling them to resist the compression and action of the abdominal muscles, which they must receive in common with the higher viscera of the belly.

By turning to the plan of the peritonæum, we find that the division of the parts in the pelvis and abdomen is not well defined; but we see that the peritonæum is reflected from the pubes over the urinary bladder, and mounts again upon the rectum. The line of division, therefore, is the peritonæum; while we understand how the bladder, which belongs to the pelvis, being distended, carries the peritonæum before it, and rises into the abdomen.

OF THE BLADDER OF URINE.

The bladder of urine must be classed with the membranous or hollow viscera. It is a bag or receptacle into which the urine slowly distils through the ureters, that it may be expelled at convenient seasons. It is

nearly of a regular oval form, when moderately distended, the ends being obtuse; but from its connections, and the pressure of surrounding parts, this regular extension is not allowed in the living body. When seen moderately distended, *in situ*, it rises somewhat pyramidal upwards; it is flat upon the os pubis on the fore part, and towards the back and lower part a portion may be seen somewhat sacculated, and below the level of the commencement of the urethra.

We describe the body, fundus, neck, and lateral parts. The fundus is the upper part; the neck is where the urethra commences, and where the prostate gland is attached; the lateral part is where, being distended, it stretches at its lower part to the sides of the pelvis.

On the fundus there is a ligamentous process, continued in a direction towards the umbilicus; this is the urachus. I would not give the name here, which is properly applicable to a tube peculiar to the fœtus of quadrupeds, were it not to add that sometimes, even in the adult human subject, there is an open tube, so that the urine passes out from the umbilicus.*

The bladder is situated higher in the boy than it is in the adult. In the fœtus it is almost entirely out of the pelvis, and reaches nearly to the umbilicus. At three years it is said to rise no more than three fingers' breadth above the os pubis; at twelve it is only about half an inch above the level of the bone; at eighteen it is said to be completely hidden behind the pubes.

When the bladder is empty, or contains only a moderate quantity of urine, it takes a triangular figure in the dead body, the base of which rests on the rectum, and the apex is attached to the back of the os pubis; and when in dissection you look down into the pelvis,

* Fernelius, de Part. Morb. et Symtom., gives an example of a man who, having an obstruction at the neck of the bladder, passed his urine by the umbilicus. Wipfer gives a similar case of a man with calculus. These are quoted by Albinus, Annot. Acad., and also the Philos. Transactions, n. 323. See also Sandifort, Thes. vol. iii. p. 234—246. Haller, Elemen. Physiol. lib. xxvi. § ii.

you find the back part of the bladder flat, and as it were stretched obliquely upon the os pubis.

STRUCTURE OF THE BLADDER. — Like the other hollow viscera, the bladder consists of several coats.

The PERITONÆAL COAT of the bladder does not surround the bladder, but only covers the fundus and back part. It is like, in every respect, to the peritonæal coat of the abdominal viscera; smooth without; and adhering to the inner coat by cellular membrane; which cellular membrane is, however, of a looser texture, and in greater quantity than under the peritonæal coat of the abdominal viscera. This peritonæal coat is no doubt of much service, as a division, in obstructing the course of inflammation arising from the diseases in the lower part of the pelvis, or from operations performed on the bladder, rectum, or perinæum; were it not for the loose peritonæum spreading over the cellular texture of the pelvis, we could neither be so bold nor so successful in our operations here. That portion of the peritonæum which covers the back part of the bladder, forms a particular transverse fold when the bladder is contracted. This fold surrounds the posterior half of the bladder, and its two extremities are stretched towards the side of the pelvis, so as to form a kind of lateral ligament.*

Though in the contracted or moderately distended state of the bladder, the peritonæum stretches from the back of the os pubis to the bladder, the distention of the bladder, in an immoderate degree, raises the peritonæum off from the pubes, so that the bladder can be struck with a trochar, or lithotomy performed above the pubes, by an incision directly into the bladder, without piercing the outer or peritonæal coat.

Towards the lower part, the bladder, as we have seen, is invested only by cellular membrane, which takes the place of the peritonæal coat of the fundus. This tissue is very loose, and permits the distention and contraction of the bladder, which looseness of texture

* See the description of the folds of the peritonæum.

is a matter of regret, when blood or urine is forced into this tissue.

MUSCULAR COAT.—The muscular coat of the bladder is very strong. Three strata of fibres are described by authors. They are so strong as to have been classed with the distinct muscles, and the whole coat has been called DETRUSOR URINÆ. Towards the lower part of the bladder the fibres are particularly strong, and formed into fasciculi, and are like a net of muscles inclosing the bladder.* These fasciculi acquire greater thickness and strength when the bladder is excited by opposition, as from stricture in the urethra.†

Towards the fore and lower part of the bladder, the muscular fibres congregate into a sort of tendon, which goes off to the back of the os pubis, which we count to be the insertion of the tendon of the bladder, and certainly this hold, which the bladder has upon the os pubis, causes it, in its contraction, to be drawn to the back of the pubes.

We have an idea of the wonderful degree of contraction in the bladder, and indeed the extent of motion in the muscular fibre in general, when we consider that the bladder extends so as to contain two pounds of urine, and contracts so as to force out the last drop from its cavity. When, however, the fibres are stretched too far, they lose the power of contraction, and often the young surgeon is deceived by what he conceives to be an incontinence of urine, while it is really an obstruction.

OF THE SPHINCTER OF THE BLADDER.

If we consider the double office of the urethra, and suppose that the seminal vessels and the ducts of the prostate gland open into the canal at a part posterior to the muscles which close the orifice of the bladder, we must be also forced to admit that there is some imper-

* Morgagni, Adversar. Anat. iii. Animad. xxxix.

† Some very remarkable examples of this may be seen in my Collection.

fection in the mechanism of these parts. For in that case, the fluids passing from those ducts would fall back into the bladder, and the orifices of the ducts would be exposed to the urine in the bladder, even when the bladder was closed. If this were really the case, it would be inconceivable how the contents of the *vesiculæ seminales* could be discharged forwards, or how the urine could be retained while the seminal discharge was made.

By such a train of reasoning I was led to look for the proper sphincter of the bladder behind the prostate. The importance of the knowledge of the complex apparatus of muscles, about the neck of the bladder, to the comprehension of the various causes of obstructed urine led me to review this part of the anatomy.

To exhibit the sphincter of the bladder, cut off all the appendages but the prostate gland; then make an incision into the fundus of the bladder and invert it. Begin the dissection by taking off the inner membrane of the bladder from around the orifice, or commencement of the urethra.

A set of fibres will be discovered on the lower half of the orifice, which, being carefully dissected, will be found to rise in a semicircular form round the urethra. These fibres make a band of about half an inch in breadth, particularly strong on the lower part of the opening; and, having mounted a little above the orifice on each side, they disperse a portion of their fibres in the substance of the bladder. A smaller and somewhat weaker set of fibres will be seen to complete their course, surrounding the orifice of the upper part; to these sphincter fibres a bridle is joined, which comes from the union of the muscles of the ureters.

Here, then, we have the muscle which closes the internal extremity of the urethra, the most posterior of all those muscles which embrace the urethra. It resembles the sphincters of the other hollow viscera; for example, those fibres which encircle the pyloric orifice of the stomach.

Third coat. — This third coat of the bladder anatomists have called the nervous and cellular coat; it

consists of very extensile white lamellæ of cellular membrane. It gives distribution to a few vessels, and connects the muscular fibres and inner coat.

The INTERNAL COAT of the bladder is very smooth on its general surface, and is bedewed with a sheathing mucus. When the bladder is distended, no inequalities are to be observed; but when contracted, it falls into folds and rugæ. From an acrid state of the urine, from strangury, from calculus, the mucous discharge is increased, even so as to form a great proportion of the fluid evacuated from the bladder. No visible source of this mucus is to be observed on the inner surface of this membrane *; so that, probably, it is a general discharge from the surface. Indeed, it appears, that no follicles or cryptæ, discharging at particular points of the surface, could have the effect of bedewing and defending the whole surface from the acrimony of the urine. †

OF THE PROSTATE GLAND.

On the neck of the bladder, and surrounding an inch of the beginning of the urethra, there is a gland nearly of the size and figure of a chestnut. This body is called the prostate gland. In all anatomy, there is not a more important subject for the attention of the surgeon than this; he must consider the size, relation and connection, and diseases of the prostate gland.

This body is round at the base which is towards the bladder, pyramidal forward. It has a lateral division, forming it into two lobes; and the older anatomists speak of it as double. Mr. Hunter and Sir Everard Home have excited our attention to the posterior or third lobe of this gland, and have drawn the most important practical remarks from the observation of this part of the anatomy. While the prostate gland sur-

* Winslow, however, describes the glands, and Heister and Haller describe follicles, near the neck of the bladder, and round the insertion of the ureters.

† When the mucous secretion is diminished by a disease of the inner membrane of the bladder, the calculous concretion more readily forms on the surface.

rounds the beginning of the urethra, it rests on the rectum, and it is tied by a fascia, or ligament, to the back part of the os pubis. The urethra passes through it; not in the middle, but towards its upper surface; so that the gland is more prominent downward, and is distinctly felt by the point of the finger *in ano*. When the catheter is introduced, and the surgeon examines the state of parts by the rectum, he will first distinguish the curve of the staff, covered with the bulb of the urethra; behind this the catheter will feel more bare of parts, but still covered with a greater thickness of parts than one should expect from the description of the membranous part of the urethra; and behind this, again, he will feel the prominence of the prostate gland, not round, distinct, and accurately defined, but gradually lost both before and behind, among the surrounding cellular membrane and muscular fibres which involve it.

The texture of the gland is a compact spongy substance, and when cut has considerable resemblance to a scirrhous gland. From each lobe there are small follicles opening into the urethra, and from these the ducts may be injected. *

It has been said, that there is really no division of this gland into lobes; but, perhaps, the best authority on this question is the morbid appearance. Now it happens sometimes that only one side of the gland is enlarged, which is a proof that there is some division betwixt the lobes. This unequal swelling of the gland distorts the urethra, and gives it a direction very difficult to be followed by the catheter. In general, when equally swelled, the greater part of the gland being beneath the urethra, the urethra is raised up, so that the point of the catheter must be raised over the enlarged gland before we can pass it into the bladder.

On the lower part of the gland, and betwixt the bladder and the vesiculæ seminales, the third portion of the gland is situated, of which Morgagni gives this account. But if any addition is to be given, says he, to the description of the prostate gland, it is that roundish and

* As first done by Monro.

smooth body like a gland, which often our very diligent dissector has shown in the public dissections. It lies prominent betwixt the bladder and seminal capsules where they are united. Upon our most accurate examination, we find this to be nothing more than a part of the prostate itself.* After this I can see no objection to calling this part of the prostate gland LOBUS MORGAGNI. Morgagni likewise observes that it is not always to be found.

The prostate gland secretes a ropy mucus. It is probable that this mucus serves to sheathe the passages, and preserve them from the acrid urine. It certainly unites also to the seminal fluid, and is discharged with it.†

The diseases of this gland form a subject too important and extended to be even hinted at here.‡

Anterior to the prostate gland, and also close to the urethra, are seated the GLANDS OF COWPER. This gland is also for the purpose of discharging mucus into the urinary passage. It is seated in that angle formed by the abrupt termination of the bulb of the spongy body of the urethra, and consequently close to the membranous part of the canal. It has a long duct, which, running forward an inch in length, terminates in the surface of the urethra. To comprehend the anatomy of the male urethra, we must first notice the structure of the penis.

* Vide Morgagni, Adversaria Anatomica, Animadversio xv. Prostatæ propago.

† Mr. Hunter says that the prostate gland undergoes changes, in its developement, corresponding with the functions of the testicle; that it shrinks and loses its natural texture in the castrated.

"The prostate gland is not common to all animals. It is wanting in the bull, buck, and most probably in all ruminating animals. In this class, the coats of the vesiculæ are much thicker and more glandular, than in those which have prostate glands. It is therefore natural to suppose that the vesiculæ answer nearly the same purposes as the prostate gland.

"The prostate gland, Cowper's glands, as well as the vesiculæ, are wanting in birds, in the amphibious animals, and these fish which have testicles, as all the ray kind."—*Animal Economy*, p. 44.

‡ For much of the anatomy and the morbid conditions of these parts, see SPECIMENS OF MORBID PARTS, *taken from the Collection of Windmill Street*. Folio. Longman and Co.

FURTHER EXAMINATION OF THE PARTS HITHERTO DESCRIBED AS SEATED AT THE NECK OF THE BLADDER —LA TRIGONE DE LA VESSIE—LA LUETTE—UVULA VESICÆ—CORPORA CARNOSA MORGAGNI—THIRD LOBE OF THE PROSTATE, ETC.

In the plates of De Graaff, there are represented certain folds, extending forward from the orifices of the ureters, where they terminate in the cavity of the bladder; and, at the lower part of the orifice of the bladder, there is a tubercle faintly indicated. The same appearance is represented by Bidloo. In Santorini also the natural appearance of these parts is accurately delineated. Morgagni expresses himself to this purpose:— "At the points where the ureters terminate in the bladder, there arises from each of them a thick, round, compact, fleshy body, which takes a direction towards the orifice of the bladder. These two bodies, having proceeded a little way, are united, and proceed forward, terminating in the Caput Gallinaceum." *

Santorini † gives the same description of these parts as Morgagni has delivered.

Lieutaud describes these bodies under the term, *La trigone de la vessie.* The learned Portal is incorrect in saying that Lieutaud was the first anatomist who has given their description.

Portal has thus described the *Trigone*: at the lower part, the internal tunic of the bladder adheres to a triangular body, of a cartilaginous hardness, and this body is always prominent in the cavity of the bladder, especially in old men. He proceeds to say, that, at the extremity of the triangle, backwards, the orifices of the ureters open; and, at their anterior extremity, there is an eminence, slightly protuberant, to which Lieutaud has given the name of *Luette.*

This account leads me again to refer to the plate

* See Morgagni, Adversaria, i. n. 9. Adversaria, iii. Animadver. xiii.

† In the Observationes Anatomicæ, cap. x, sec. xxi.

of the excellent anatomist, Dominico Santorini. In his second table, the Luette and Trigone are accurately represented.

He has the following explanation on the letter I:— "Vesicæ urinæ osculum, cui prominulum corpus præfigitur, quod in affectis vesicæ sic prominet aliquando ut urinæ iter prorsus intercludat." This refers to the disease with which Mr. Hunter and Sir E. Home have made us familiar.

The expression of Santorini recalls us again to the remark of Portal. He says, "I have found in old men, who have suffered retention of urine, the *Trigone de la Vessie* so enlarged, especially its tubercle, in the form of an uvula (Luette), that the orifice of the bladder was shut by it." *

Sabatier follows his countryman in his description of this part of the bladder, but adds, "The *Trigone* and *Luette* are the most sensible parts of the bladder; which is the cause why a stone lodging here produces extreme irritation, while, if it lodges in any other part of the cavity of the bladder, it causes little inconvenience." He adds, "The uvula (*Luette*), which terminates the anterior angle, is very subject to swell, and then it rises in the form of a round tumour, which fills the neck of the bladder, and opposes itself to the flow of urine." †

Dessault, speaking of the tumours which grow in the bladder, has this expression:—"Le sommet de ce viscère n'en est pas plus exempt que son bas-fond; mais ce sont particulièrement ceux qui croissent près de son col, et que quelques auteurs ont pris pour un gonflement de la luette vésicale, qui occasionnent la rétention d'urine."

This sentence, which betrays the imperfect knowledge which Dessault had of the disease, is followed by other unequivocal marks of unconfirmed principles and practice; and the whole chapter stands in remarkable contrast with the publication of Sir E. Home, in this country.

* Portal, Cours d'Anatomie Méd. t. v. p. 109.

† See also Lieutaud, Hist. Anatomic. Medica. Tumores Vesicæ adnati.

In Haller's *Element. Physiolog.** we have a description, following that of Morgagni, under the title *Colliculi ab Ureteribus in Urethram producti.*

These authorities being discussed, we come now to the more modern observation of Mr. Hunter.

Mr. Hunter † has described a small portion of the prostate gland, which lies behind the very beginning of the urethra; and this he describes as subject to swell out like a point, in the cavity of the bladder, where it acts like a valve on the mouth of the urethra. This can be seen even when the swelling is not considerable, by looking upon the mouth of the urethra from the cavity of the bladder.

It is impossible to mistake this; the swelling he describes is the *Uvula Vesicæ*, or *Luette* of Lieutaud. The observations of Mr. Hunter then, go to inform us, that this tumour is of that part of the prostate gland which is below the urethra, and betwixt the lateral portions of the gland.

This discovery carries us back to the great anatomists in whose works we find the elements of all our present knowledge. Morgagni, we have seen, has very fully described the part of the prostate gland, which Mr. Hunter mentions, and which he discovered to be the seat of this dangerous malady. ‡

In addition to the description of Morgagni we have the authority of Sabatier. "Sometimes," says he, "only that part of the prostate is diseased to which they have given the name of *Luette Vésicale.* I have seen several occasions," he continues, "in which the uvula forms a tumour, with a narrow peduncle: this moving with a stream of urine, closed the opening of the bladder." §

* T. v. p. 328. † P. 170.
‡ Morgagni, Adversaria Anat. iv. Animad. xv.
§ Med. Operat. t. ii. p. 72.

ANATOMY OF THE NECK OF THE BLADDER.

On dissecting up the inner coat of the bladder, there are seen two strong fleshy columns, which descend from the orifices of the ureters towards the orifice of the bladder: they unite and run towards the prostate gland.* On the surface, towards the cavity of the bladder, they are denser by the union of the inner coat of the bladder, but they are fibrous, and this fibrous structure is made manifest by dissection from below. They are larger and firmer, but of the same colour and structure with the fleshy columns of the *Detrusor urinæ.* The variety which we find in their length according with the degree of contraction of the bladder, proves their muscularity. Whatever excites the action of the bladder increases the size of these muscles in a remarkable degree; and they always acquire a great increase of power and size when the muscular coat of the bladder becomes more distinct and powerful. In some of my specimens of diseased bladder, I find the cause of this to be stone in the bladder; in others, an ulcer; in many, stricture; but always irritation and the necessity of continual action of the bladder are attended with an enlargement of the muscles of the ureters.

When contracted, the course of these columns is distinguishable all the way from the mouths of the ureters to the beginning of the urethra; and there, at their union, they heave up the inner coat of the bladder, producing the appearance of a tubercle at the lower part of the orifice of the bladder.†

It is still the form of the inner coat which makes these fleshy columns appear to terminate forward in the caput gallinaceum, which they do not; they only take a firmer insertion. Where these columns unite they are

* See the Gulstonian Lectures by Wm. Rutty, M.D. Treatise on the Urinary Passages, and a Description of their Power and Uses.

† It is this appearance presented by the muscles in a state of contraction, which has led so many of our best authorities to confound it with the disease of the third lobe of the prostate gland.

most fleshy, and their fibres are most intricate; then, directing their course towards the lower and backmost part of the prostate, they degenerate into tendon, and are inserted into the portion called the third lobe of the prostate.

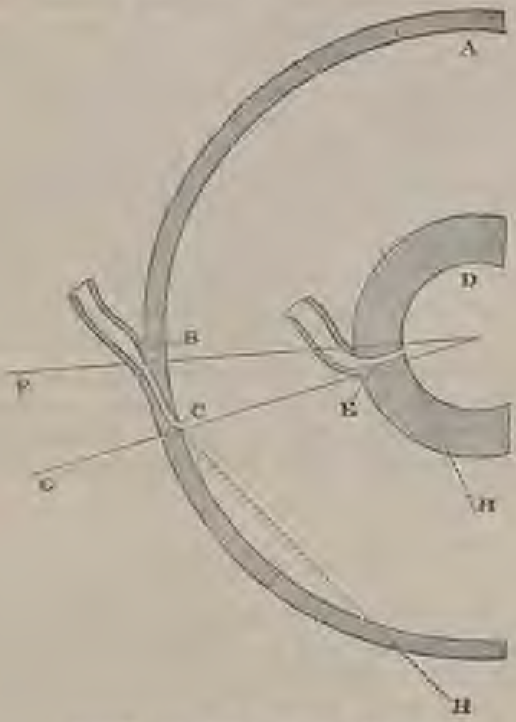
Although I have described the course of these muscles as proceeding from the back part forward, because it better corresponds with the first view we have of them, yet, I believe, it is more correct to consider their connection with the prostate gland as the fixed point, and their connection with the extremities of the ureters as their insertion.

USE. — The use of these muscles is, to assist in the contraction of the bladder, and at the same time to close and support the mouths of the ureters. The surface of the bladder, where it covers their union on the inside, is endowed with an exquisite sensibility, which is a provision of nature for their ready and instantaneous action on the stimulus to pass the urine. It is here that is seated that sensibility which produces the natural call to pass urine, and here also is the seat of diseased irritations.

It will be observed, that the orifices of the ureters are not closed by the contraction of the muscular fibres around them. They are defended against the return of the urine by the obliquity of their passage through the coats of the bladder. It is well known that the extremity of the ureters enter through the coats of the bladder obliquely; and that, in consequence of this, there is a valvular action in the coats of the bladder, which prevents the regurgitation of the urine into the ducts of the kidney.

But if we look to the adjoining diagram, and consider the subject, we shall find, that in proportion as the bladder contracts, this obliquity must be diminished. And further, if we reflect that the coat, which contracts, is on the outside of the oblique passage of the ureter, we shall conclude that without some counteracting power on the inside of the bladder to draw down the orifice of the ureter, the obliquity of the passage would be lost. These muscles, which I have now described,

guard the orifices of the ureters by preserving the obliquity of the passage, and by pulling down the extremities of the ureters according to the degree of the contraction of the bladder generally.*



* EXPLANATION OF THE DIAGRAM.

Let A represent the circle of the dilated bladder: B, the ureter or duct of the kidney entering the coats of the bladder: C, the extremity of the duct opening on the inside of the bladder: B, C, mark the oblique course of the ureter through the coats of the bladder. Let D represent the contracted bladder, thickened at the same time by its contraction: E, the ureter passing through the coats.

The lines F, G, drawn from the centre of the circle, will intersect corresponding portions of both circles, and demonstrate how the oblique passage of the ureter, through the coats of the dilated bladder, becomes more direct in the contracted bladder.

The muscles described act in the direction of the lines H, H, and their operation is to draw down the orifice of the ureter C, in proportion as the bladder contracts, by which means the obliquity of the passage is preserved.

The membrane, which covers these muscles, is the seat of that sense which calls the muscular coat of the bladder into action. Of this we may be sensible in passing the bougie, and still more in passing the urethra sound. As the instrument is passed down the urethra, there is a sickening sensation; as it passes the caput gallinaceum, the nature of the pain is changed; and, lastly, in passing it over the surface of the triangular elevation, produced by these muscles, there is experienced the familiar sensation of the call to pass urine. If it were doubted that here, in a particular manner, is seated that sensibility which calls the bladder into action, the effect of a stone falling upon the part is sufficient proof. When a patient has a stone in the bladder, there is pain and excitement while it rests in this place, and relief when it lodges elsewhere. The reason why this part is possessed of such sensibility I apprehend to be, that the muscles of the ureters may, as it were, be the first alarmed, in order to guard the mouth of the ureters, and preserve their obliquity during the action of the bladder.

ACTION IN DISEASE.

When the sensibility in the seat of these muscles is increased by disease, and the increased sensibility is accompanied with a continual action of the muscles, the prostate gland must suffer unusual excitement. The natural prominence formed by the muscles being directly over the third lobe of the prostate, and their chief attachment being also to this third lobe, we may perceive how it happens that this part is sometimes enlarged without the body of the prostate gland partaking much in the disease. When there is an unusual *nisus* of the bladder, these muscles are the seat of it; and as their united extremities are attached to the lower and middle portion of the prostate gland, they must, I think, promote the growth of this portion in a direction towards the cavity of the bladder. This will produce the true *uvula vesicæ*, the pendulous tumour in the neck of the bladder resembling the uvula of the palate. This

tumour hangs into the cavity of the bladder, and falls like a valve upon the orifice of the bladder, proving a most troublesome and dangerous obstruction to the urine.

But whilst I state this as an opinion, drawn from the consideration of the parts in their natural state, I must also submit the naked facts. I have, in my Collection, two specimens of the disease of the third lobe of the prostate, where these muscles are remarkably strong. I have, on the other hand, some specimens of diseased bladder, where the muscles of the ureters are enlarged; and only in one of these is there a beginning enlargement of the middle lobe of the prostate gland.

I have many specimens of bone distorted by the action of the muscles; and many, where, at the attachments of the tendons, the bones are drawn out into spines and tubercles. We may say, such is the effect of the muscles; but though the growth of such spines or tubercles be the effect of the action of the muscles directly, yet these spines will not be formed unless when the bones are at the same time suffering from disease. So, in considering the action of the muscles of the ureters, as influencing the growth of the prostate in a particular direction, I do not imagine that the muscles will do this merely by their mechanical effect. There must be also a disposition to disease in the prostate; and if disease be not present, the irritation of the bladder will continue even till the death of the patient, without affecting the growth of the gland.

On the extremities of the ureters, in the diseased action of the bladder, the contraction of these muscles is converted from a salutary influence to one which aggravates disease. They still close the mouths of the ureters during the action of the bladder; and the action continuing, they cause an accumulation in the ureters and pelvis of the kidney, and influence the kidney itself, thus increasing the extent of the local disorder, and, consequently, its influence on the constitution.

Such consequences as arise from the irritation and action of these muscles are to be relieved by removing the cause, by assuaging the sensibility of the surface

of the tubercle, and by drawing off the urine. When we know that this spot on the lower part of the orifice of the bladder is the seat of that irritability which is so distressing, we see that it is practicable to effect it by the use of the bougie. By the introduction of the catheter, the urine is let off without hinderance from the valve, the distressing excitement of the muscles is not perpetuated, and the prostate subsides from its irritation.

This practice, though a direct deduction from the examination I have made, is no more than the advice given to us by the best authors.

Thus we see that a small tubercle was painted by De Graaff, and described by others, but the nature and origin of the tubercle was misconceived. Anatomists were calling it *uvula vesicæ*, as if that natural prominence was the same with the *tumour* of this part of the bladder. We find that the disease called *uvula vesicæ* is no other than that occasioned by the enlargement of the third lobe of the prostate gland. To Mr. Hunter and Sir E. Home we are indebted for a full knowledge of the nature of this disease. It has been objected to Sir E. Home, that he is in vain making that important, which the great anatomists of all ages have failed to discover, or have neglected to notice. I have shown that the third lobe of the prostate was known to Morgagni, and that it was a subject of discussion in his day. We have sufficient evidence (even on this very subject) of the difference of a fact being noticed in the elaborate works of Morgagni, and of its being familiarly and practically known to surgeons. The third lobe of the prostate was quite forgotten; the consequence was that we were ignorant of the nature of the most fatal disease of the bladder. It would be disingenuously reserving the circumstance which drew me to attend to this subject, were I to omit the mention of the late work of Sir E. Home, or rather his original paper on the anatomy of the prostate gland. I acknowledge both the merit and the necessity of what he has written; for the observation of Morgagni and the hint of Sabatier were forgotten both here and in France, until the subject was distinctly and practically brought forward by Sir E.

Home. Even the latest French author, Richerand *, still speaks of the enlargement of the anterior angle of the "*trigone vesicale*," and the growth of *fungosities* near the neck of the bladder, obstructing the course of the urine.

It still remained to be explained, why the small part of the prostate gland, the third lobe of Sir E. Home, should be so frequently enlarged, without the affection of the body generally being apparent, or why this part should enlarge more rapidly than the rest of the gland. It was in the prosecution of this enquiry, that I discovered the muscles of the ureters; and after ascertaining their nature, I saw through the obscurities of authors, in treating of the diseases of this part of the bladder; so that in speaking of the enlargement of the anterior extremity of a natural tubercle, they were deceived; and that, in treating of the *uvula*, they were describing the diseased prostate gland.

OF THE PENIS, URETHRA, AND TESTES.

STRUCTURE OF THE PENIS.

The penis consists of a spongy substance, admitting venous blood, and supported by a very firm elastic covering which restrains the over distention, and gives the form. There are properly three spongy bodies. Two of these bodies are called the CORPORA CAVERNOSA PENIS; they form the body of the penis: the other is the CORPUS SPONGIOSUM URETHRÆ, a vesicular and spongy substance, which surrounds the whole length of the urethra, and expands into the bulb of the urethra in the perinæum, and into the glans on the point of the penis.

CORPORA CAVERNOSA. — The body of the penis consists of two tubes formed of a very strong sheath. This sheath has a great degree of elasticity; but at its utmost

* Nosographie Chirurgicale, 2d ed. p. 458.

extension powerfully resists the farther distention with blood. These tubes are united in the greater part of the length of the penis, or rather they are parted only by an imperfect partition. Within them is a curious tissue which forms a cellular texture; into this texture the arteries pour their blood so as to occasion erection. The posterior extremities of these cavernous tubes are called CRURA PENIS: they separate in the perinæum, and each of them takes hold on the ramus of the os pubis. Forward, these cavernous bodies or tubes terminate in rounded points under the glans penis.

This internal tissue consists of cells connected with each other, and having a free communication through the whole extent of the penis. They are interposed betwixt the extremities of the arteries and veins, or probably while the arteries have communication, and open into the extremities of the veins, in the common way: they have such connections with this cellular structure, that in accelerated or excited action they pour their blood into them; yet in such a manner, that the blood circulates in the penis during erection as at other times, and the blood in the cavernous body is not stagnant.*

CORPUS SPONGIOSUM URETHRÆ. — Attached to the cavernous body of the penis there is a spongy body similar in structure: through this cellular or cavernous texture the canal for the urine, called urethra, takes its course, which gives rise to the name spongy body of the urethra, or *corpus spongiosum urethræ*.

The spongy body extends the whole length of the penis; and where it extends backwards into the perinæum, betwixt the crura of the penis, it is enlarged

* The figure represents a section of the distended and dried Penis. A. Theca or sheath of the Penis. B. Corpus Cavernosum. C. Septum Pectiniforme. D. Corpus Cavernosum Minus, or spongiosum Urethræ. E. the lesser Septa of the Corpus Cavernosum.

into a round head, which is called the *bulbous part*:— it is upon this, and on about an inch and a half of the lower part of the spongy body, that the ejaculator seminis or accelerator urinæ acts; and, as within this enlargement of the spongy body which surrounds the urethra there is a dilatation of the tube of the urethra itself, the use of the muscle is evident. It contracts upon this sinus of the urethra when distended with the discharge of the vesiculæ, the prostate gland, and testicle.

Forward, at the extremity of the penis, the spongy body is enlarged into the glans; thus forming the bulbous head of the penis which crowns the conical extremities of the cavernous body.

The spongy substance which we have described, admitting the blood freely into its cells, suffers erection at the same time with the body of the penis; and as the blood of the glans has free connection with the blood of the bulb seated in the urethra, we may perceive that the action of the ejaculator seminis upon the back part of the spongy body must affect the whole extent of that body and the glans also. The excitement of the glans gives the action to the accelerator or ejaculator muscle: the action of this muscle compresses the bulb, and in consequence the whole spongy body to the extremity of the glans is made turgid, and thereby diminishes the diameter of the urethra, adapting it to the emission of semen. Sir Everard Home, I observe, supposes "that an action takes place in the membrane of the urethra, to reduce the size of the canal, and fit it for throwing out the semen with the necessary velocity." I imagine, the action of the accelerator, and the state of distention of the spongy body resulting from it, will have this effect.

The obtuse glans spread upon the extremities of the cavernous bodies of the penis has no communication with them. We observe a posterior circular margin on the glans; this is the *corona glandis*, and behind this there is a depression called the cervix. About the corona and cervix there are many little glandular bodies.*

* Glandulæ odoriferæ of Tyson. See Morgagni Adversar. iv. Animad. xii. et sequent. *de Tuberculis Coronæ Penis.*

The PRÆPUTIUM is a loose prolongation of the integuments of the penis, which hangs over and defends the delicate and sensible surface of the glans. Its inner surface is continued from the common integuments; this is again reflected over the glans. Upon the lower side, and just behind the opening of the urethra, the præputium is tied in a particular manner to the surface of the glans. This connection limits the motion of the præputium, and is called FRÆNUM PRÆPUTII.

The whole integuments of the penis are of the same cellular structure with those of the rest of the body: they are particularly loose and distensible, and unincumbered with fat. We may see them in emphysema and in œdema monstrously distended.

OF THE URETHRA.

The urethra is the canal for emptying the bladder. It extends from the neck of the bladder to the extremity of the penis. It is formed of the continuation of the inner and third coat of the bladder; which last forms a reticular membrane, uniting the inner membrane to the spongy body. It is, however, supported through all its length, near the bladder, by passing through the prostate gland and sphincter fibres; further forward than this, where it passes from the prostate to the beginning of the spongy body of the urethra, it is invested and supported by firm ligamentous membranes and muscles; and in all the length of the penis it is included in the spongy body, which extends from the bulb to the glans. It cannot be described as a cylindrical canal, for it is closed unless distended with urine, and admits of very unequal distention. It begins large at the neck of the bladder; where, immersed in the prostate gland, it forms a little sinus; it is contracted again in a remarkable degree behind the bulb; it dilates into the SINUS of the URETHRA within the bulbous enlargement of the spongy body; it is gradually diminished forward; and it may be considered as cylindrical or equal in its diameter from this part forward to the point of the glans, where it is much contracted. There is still another

sinus or dilatation of the canal described, the *fossa navicularis*, where the urethra is surrounded by the glans.*

The canal of the urethra is bedewed with mucus. The sources of this mucus are here particularly apparent; bristles to the amount of seventy may be admitted in the mouths of the little ducts. Besides the general surface and the glands which I have described, there are large lacunæ observable; into which mucus is secreted, and from which, as from receptacles, it is pressed out as the urine flows.† The inner membrane of the urethra is very delicate, and, when torn by the catheter, or by violent chordee, or opened by the caustic, bleeds profusely.

The internal membranes of the bladder and urethra are particularly sensible; drawing after them, when excited, not only the action of all the muscles in the lower part of the pelvis, but having sympathies in a particular manner with the testicle, stomach, and bowels, and with the whole system. The more curious and important effect of the injury of the urethra is the paroxysm of fever which it induces. Observing the regular occurrence of an intermitting fever in cases of fistula in the perinæum, we should imagine it to be the effect of the extravasation of the urine in the cellular membrane, and the effect of general irritation; until it is observed that the simple stricture produces that effect, and that a touch of the caustic brings on a violent paroxysm.

When the reticular membrane is inflamed, of course it loses its elasticity, and gives pain in erection. Sometimes the inflammation, being continued to the spongy body surrounding the urethra, makes it unequal in its

* Haller Com. lib. xxvii. sect. 1. § xxx. Sir E. Home on Strictures. Observ. de partibus genitalibus sexus potioris Sandif. Thes. VIII. p. 71.

† These are the *Canaliculi Morgagni*, Advers. Anat. — De glandulis urethræ, vide Morgagni Adversar. iv. An. vii. et. sequent. There is much controversy and much confusion regarding the glands of the urethra, viz. *Prostatæ minores; glandulæ Cowperianæ; glandulæ Littreanæ, &c.* The reason of which I believe to be that the *lacunæ* do not appear glandular unless when they have suffered by inflammation: there is no round smooth body attached to them, unless their secretions have been increased, and the cellular membrane and vessels are condensed around the lacunæ.

capacity of distention to the cavernous bodies of the penis, and sometimes their cells are united by adhesion in the worst cases of chordee.

I cannot imagine, with some, that the urethra is muscular; *first*, because I see no end it could serve in the economy; *secondly*, because there is no proof in support of the opinion; *thirdly*, because it is surrounded with strong fibres and a spongy body, which conjointly seem calculated for every purpose of the economy, and likely to account for every symptom which might be mistaken for spasmodic action in the canal itself. The idea of muscularity is derived from the symptoms of stricture and the irritability of the canal.*

The urethra is very elastic; not only allowing a very large bougie to be passed, and closing upon a thread, but it still more remarkably admits of elongation than of distention in the width of the canal. It is surrounded, as we have seen, with a spongy body and the cellular coat which is betwixt the delicate lining membrane of the urethra, and the spongy body partakes of the structure of both, and is very elastic. But when an inflammation attacks the canal, this cellular membrane is its principal seat. The point affected loses its elasticity; no longer stretches with the penis and urethra, but consolidates, or forms a strong membranous filament. To suppose this stricture to have been formed by the muscular contraction, in the diameter of the canal, would be to allow the partial action of one or two fibres, (for the stricture is like that which would be produced by the tying of a packthread round the canal, being a narrow circular ridge,) which is very unlikely. Sometimes, however, the stricture is only on one side of the canal, which, allowing it to be formed by inflammation, is very likely to happen: but, in consequence of the muscular action, cannot easily be supposed to take place, since

* Morgagni describes the membrane of the urethra as double, having vessels betwixt it laminæ. These are the veins described by Dr. Barclay. Observ. Anat. p. 1. tab. iv. J. C. Brims, Sand. Thes. VIII., describes two laminæ, one of which he considers to be the continuation of the muscular coat of the bladder. See a paper of Mr. Shaw's in the Medic. Chirurg. Trans.

the drawing of the muscular fibres would equally affect the whole circle.

As to the effect of heat and cold on an obstruction, it may be explained easily, without the supposition of muscular contraction: for as we know that the spongy bodies, and of course the whole canal, relax and elongate in warmth, as they are shrunk up and contracted in cold, like the skin of the body in general, without implying muscular contraction: so we see how this state would affect a stricture; — that, when the penis and the urethra were shrunk, the effect of the stricture would be increased, and the patient could pass his urine only when the parts were relaxed, by sitting in a warm room, or by the use of the bath.

But when surgeons speak of spasms of the urethra, they seem to forget the action of the surrounding muscles. Thus acrid and stimulating urine, or an irritable state of the urethra, will be followed by a small stream of urine; or, perhaps, a temporary obstruction is the consequence: but why should we suppose that the membrane of the urethra, which has no appearance of muscularity, causes this effect, when it is probably produced by the sphincter muscles, the fibres which surround the membranous part of the urethra, the levator ani, and, above all, by the accelerator urinæ, a muscular sheath of fibres surrounding three or four inches of the canal. Round the membranous part of the urethra, and behind the bulb, there is much interlacing of muscular fibres; and the levator ani, splitting, embraces it. Round the sinus of the urethra, and the bulb which covers it, is the accelerator urinæ, more properly the ejaculator seminis. In short, here is a whole class of muscles which sympathise with the state of the urethra; and these muscles, disordered in their action when the canal is inflamed, give occasion to those contractions which are attributed to the membrane of the urethra itself.

OF THE TESTES.

The TESTICLE might be considered as more naturally connected with the abdominal viscera than with those

of the pelvis, as its original seat is on the loins amongst the abdominal viscera, and as it receives its coats from the peritonæum, its vessels from the abdominal vessels, and its nerves from the plexus belonging to the vital parts.

The testicles are two glandular bodies, which secrete the semen: they are seated in the scrotum, and are covered and protected by several coats; they receive their vessels from the aorta and cava, or the emulgent vessels; their excretory ducts run up into the belly, and terminate in the urethra near the neck of the bladder.

The SCROTUM, in which the testicles are lodged, is a continuation of the common integuments: its cellular membrane is particularly lax and free from fat, and the water of anasarca is extremely apt to fall down into it, so as sometimes to distend the scrotum to a transparent bag of enormous size; and not unfrequently the cellular texture here has been blown up to counterfeit rupture and other diseases.

OF THE DARTOS. — The cellular substance of the scrotum is peculiar in its appearance, being red and fibrous. It has been considered as a muscle, and called DARTOS *, although this is denied by many. Its action is to support and brace the scrotum; and in bad health †, and in old age, it is so much relaxed as to allow the testicles to hang upon the cords. But besides the simple corrugation and relaxation, the scrotum has a motion like the vermicular motion of the intestines, obliquely and irregularly from side to side. Its contraction has a relation to the healthy secretion of the gland within; and when for some obstinate disease of the body of the testicle blisters are applied to the scrotum, we may see this muscle, in great activity, rolling round the testicles. The straight fibres of the *cremaster* muscle could not, I imagine, perform this revolving motion, and therefore I conclude that the dartos is a muscle, on a testimony better than is to be had from dissection.

There may be traced from the web of cellular mem-

* Δαρτος, Veterum.

† Nurses attend to the state of the scrotum in children.

brane which covers the abdominal muscle a kind of imperfect expansion descending upon the testicles. This becomes very strong when hernia has taken place at the ring.*

SEPTUM. — Upon the surface of the scrotum, directly in the middle, there is a line passing from the lower part of the penis to the anus — the RAPHA. This line marks a division in the scrotum, a partition, or septum, which divides the scrotum into two distinct cellular beds for the testicles.

COATS OF THE TESTICLE. — The *cremaster* muscle is expanded over the proper coats of the testicle. The origin of this muscle (as we have seen in Vol. I.) is from the internal oblique muscle of the abdomen: it passes through the hole of the external oblique muscle, called the *ring*, and descends over the vessels to the testicle, constituting a part of the cord, and finally spreading its fibres over the *tunica vaginalis testis*. Its use is to suspend and draw up the body of the testicle.

Under the fibres of the muscle we may discover a process of cellular membrane which comes down from the cellular membrane behind the peritonæum, and has been usually called a process of the peritonæum, even before the coats of the testicle were discovered to be originally formed by that membrane.

Besides the involving scrotum, each testicle has distinct coats. The TUNICA VAGINALIS, according to our best authors, covers the testicle loosely; that is, without adhering to its general surface: but the albuginea is in close union with it, and is the immediate coat of the testicle. The inner surface of the vaginal coat is perfectly smooth, and an exudation is poured out from it, as from the peritonæum within the belly. The outer surface of the tunica albuginea is also smooth and firm, and white, whence its name; but, on its inner surface, like the peritonæum, which covers the intestine, and adheres to the muscular coat, it adheres to the proper substance of the testicle. These investing coats are in some respects dis-

* *Mouchart* de Hern. p. 14. tab. ii. *Garengeot*. *Haller*. Monro. — I have during operation separated this into three laminæ.

similar, yet in general much alike, one being continued into the other, and both prolongations of the peritonæum. The outer membrane, the tunica vaginalis, is a protection to the testicle, by gliding easily on the inner coat; and aided by the mobility of the cellular membrane of the dartos, it preserves the testicles from bruises and strokes, to which it would be exposed if it were more firmly attached. The inner tunic, or albuginea, gives strength and firmness to the substance of the testicle. Betwixt these coats is the fluid collected which forms the hydrocele. They also contain the congenital hernia; but the common hernia is without both coats of the testicle. To understand the anatomy of this part thoroughly, we must attend to the descent of the testicle, and to the manner in which these coats are formed.

OF THE DESCENT OF THE TESTICLE.*

In the fœtus, some months before birth, the testicles are lodged in the belly, and are, in every respect, like the abdominal viscera. They are seated on the fore part of the psoæ muscles, by the side of the rectum. They are covered and invested by the peritonæum; for as we have explained how the solid viscera and the intestines are behind the peritonæum, so it will be understood how the testicles, lying on the loins, are behind the peritonæum; that is to say, the glandular substance of the testicle is invested by a coat, and that coat is the peritonæum, which, after covering the body of the testicle, is reflected upon the loins; as the coats of the liver, for example, are to be traced from its surface to the diaphragm. No words, however, can well explain this subject, and it will be better understood by these plans.

* Dr. W. Hunter discovered the situation of the testes in the abdomen of the fœtus, and suggested this to his brother as a subject of investigation. Mr. J. Hunter distinctly described the anatomy of the descent of the testicle, and explained the formation of its coats. See his *Animal Economy*. In reading *Kerckringius* one is apt to believe he understood the nature of the descent of the testicle. Spicilegium Anatomicum, p. 35.

FIRST PLAN OF THE TESTICLE.

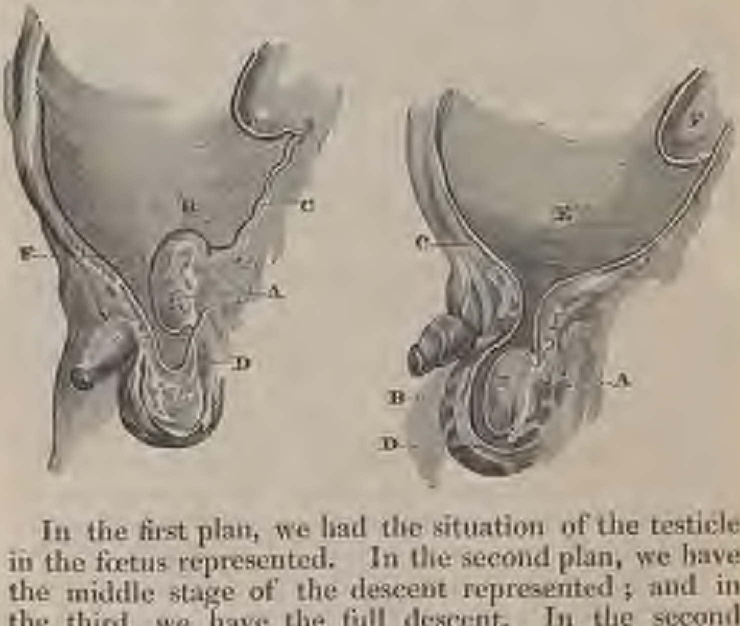
We see that the body of the testicle A is seated on the loins, that it is attached by vessels, and invested by the peritonæum. This surrounding of the body of the testicle by the peritonæum forms that coat which is in union with its substance, and which descends with it into the scrotum, and forms the tunica albuginea.

The figure and presenting surfaces of the testicle, while within the belly, are the same which we find after it has descended into the scrotum. It stands edgeways forward, and the epididymis lies along the outside of the posterior edge of the testes. We see that it is attached, by the peritoneum being reflected off from its back part, and we can trace the peritonæum upwards over the kidney G, and downward over the rectum F, and bladder of urine E.

We may also observe a process of the peritonæum which has passed through the abdominal ring, and which in this plan is marked D. Now it may easily be understood, that the testicle A, gradually shifting its place from its connections in the loins, drops down into this sheath D. It will also be easily understood how the testicle, covered with its first coat B (viz. the tunica albuginea), when it has fallen into D, is invested by this sac of the peritonæum, and that this last covering will come to be the tunica vaginalis. The tunica vaginalis is so called, because it covers the testicle like a sheath; that is, it does not universally adhere to the surface of the albuginea, as that coat does to the body of the testicle.

Understanding the nature of the peritonæum, we may learn the meaning of this looseness of the outer coat of the testicle. By turning to the introductory section of the abdominal muscles, we find, that the inside of the sac of the peritonæum is smooth, and forms no adhesion, whilst the outer surface, being in contact with the substance of the several viscera, has a connection with them by a common cellular membrane. Now, as the inside of the peritonæum does not adhere, as the surface of the peritonæum (which in this first plan is towards C), is smooth, and has no tendency to unite with the surface of the viscera; so neither has the surface of the peritonæum at D the tendency to unite with the peritonæum (or the surface of the albuginea) at B, when it descends to meet it; consequently the coat of the intestines may be represented in this second plan, thus:—

SECOND AND THIRD PLANS OF THE TESTICLE.



In the first plan, we had the situation of the testicle in the fœtus represented. In the second plan, we have the middle stage of the descent represented; and in the third, we have the full descent. In the second figure, A is the body of the testicle, B is the first peritonæal covering, or tunica albuginea, which can be easily

traced, reflected off from the loins at C; again, D is the portion of the peritonæum, which, having descended before the testicle, is presently, when the testicle has fully descended, to become the second, or vaginal coat of the testicle; F is the continuation of the peritonæum upon the inside of the abdominal muscles.

In the third figure of this series, we find the testicle A has descended into the scrotum; that it has one coat covering it, which we recognise to be the same with B, in the first figure, and that the peritonæum in this third plate at B can be traced to C, the peritonæum within the belly.

Now, supposing this to be the state of the testicle immediately after it has descended, we see that there is still a communication betwixt the cavity of the tunica vaginalis D, and the cavity of the peritonæum E. F is the kidney covered by the peritonæum, and nearly in the situation in which the testicle was before its descent.

FOURTH PLAN OF THE TESTICLE.

From this fourth plan of the testicle, we may learn the nature of the congenital hernia. It is a hernia produced by the intestine slipping down from the communication betwixt the general cavity of the peritonæum and the cavity of the tunica vaginalis, or in consequence of an adhesion betwixt the testicle and a portion of the gut, which of course causes the gut to follow the testicle, and prevents the communication betwixt the belly and the cavity of the tunica vaginalis from being shut. Thus in fig. 4. A is the testicle as seen in plan 3.; B, the tunica

albuginea; C, the peritonæum within the belly; D, the tunica vaginalis, which we can trace from C, and which is distended and separated from the surface of the testicle (*i. e.* of the albuginea), by a portion of the gut, which has descended through the ring; E, the point of reflection; F, the intestines within the belly; G, the intestine which has fallen into the tunica vaginalis, and is in contact with the testicle; that is, in contact with the tunica vaginalis, which is in close union with the gland, and is considered as its surface.

We have explained the change which takes place in the situation of the testicle, as it relates to the peritonæum; but how this change is brought about, it is very difficult to understand. It is not a sudden pulling down of the testicle, but a very gradual process, continuing for months: it is not the effect of gravitation, for the fœtus may be in every variety of posture while in the womb, and generally the head presents. It is not respiration. Is it, then, the effect of the action of the cremaster muscle? or must we refer it to a law such as that which controls and directs the growth of parts?

When the parts in a fœtus before the descent of the testicle are dissected, there is found a ligamentous, or cellular cord, mingled with the fibres of the cremaster muscle, and which takes its origin from the groin, is reflected into the abdominal ring, and stretches up to the body of the testicle. This body is called ligament, or gubernaculum, and to the agency of this bundle of fibres is the descent of the testicle attributed. There are, however, objections to this. If we suppose that the cremaster muscle, by its exertion, brings down the testicle to the ring, how does it pass the ring? For surely we cannot suppose that this muscle, which takes its origin from the internal oblique muscle, consequently within, can contract, not only so as to bring the testicle to the very point of its origin, but to protrude it past that point, and through the tendon of the external oblique muscle. Animals have the cremaster muscle, whose testicles never descend out of the belly;—again, the vessels of the cord, before the testicle has fully de-

scended, show no marks of being dragged down, for they are elegantly tortuous.

As the testicle passes very slowly from the loins to the ring; so, after it has escaped from the belly, it passes slowly from the ring to the bottom of the scrotum. It commonly remains some time by the side of the penis, and only by degrees descends to the bottom of the scrotum.*

In this change the testicles do not fall loose into the elongation of the peritonæum like a piece of gut or omentum in a rupture; — but carrying the peritonæum with them, they continue to adhere to the parts behind them, as they did to the psoas muscle while in the loins; a point of importance to be recollected.

The communication betwixt the belly and the sac of the vaginalis is very soon obliterated by the adhesion of the upper part, and then the whole extent of the passage (viz. from E to D, in plan third of this series) is shut. When this process is prevented in the first instance, and nature is baulked in the humour of doing her work, as Mr. Hunter observes, she cannot so easily do it afterwards.

It has also occurred, that this communication remaining after birth, a hydrocele has been produced, owing to the distention of the tunica vaginalis, by fluids descending from the belly. The character of such a tumour will be, that the fluid may be easily forced into the belly. It may be mistaken for a congenital hernia.

It will already be understood, that in the common hernia of the groin or scrotum, the gut does not pass by the communication from the belly into the vaginal coat; that such communication no longer exists, and that when there is a rupture from preternatural wideness of the abdominal ring, or in consequence of a great vio-

* Mr. Hunter has shown, that the detention of the testicle in the belly is in consequence of some defect and want of action in the testicle, and that those who have the testicle remaining in the belly have it imperfect or small. This is contrary to an old authority; — The testicles are seated externally, "for chastity's sake; for such live wights as have their stones hid within their body are very lecherous, do often couple, and get many young ones."

lence, a new portion of the peritonæum descends with the gut before the cord of the testicle.

FIFTH PLAN OF THE TESTICLE.

This fifth plan will now illustrate the relation of the testicle to the herniary sac in the common scrotal hernia. A, the scrotum: B, the testicle; which will be easily understood to preserve its attachment to the back part of the scrotum: C, the tunica vaginalis, which here invests the testicle, but which is not now (in the adult or perfect state of the coats of the testicle), as is seen in plan third, open from D to E, but forms a short sac, surrounding the tunica albuginea: D, the cellular membrane of the cord of vessels passing down to the testicle. And now there are no remains of the tube of communication betwixt the belly and vaginal cavity; it is obliterated and resolved into this cellular membrane.

We see, then, that in this plan the testicle and its coats, and the spermatic cord, are in their natural situation, and that the herniary sac has descended before them. E, is the ring of the external oblique muscle of the abdomen, through which not only the testicle, with its coats and vessels, has descended, but also the hernia; F, the herniary sac, which contains a portion of the gut; it is formed of the peritonæum, fallen down from the belly, but it is quite distinct from the sac of the tunica vaginalis C. Whilst this new process of the abdominal peritonæum has descended, it has contracted adhesions, and cannot now be replaced.

In thus explaining these important principles of anatomy, which the anatomical student will find wonderfully to facilitate the more minute study of surgical anatomy, it only remains to show the nature of the hydrocele.

The hydrocele is a collection of water within the sac of the tunica vaginalis; that is, betwixt the tunica vaginalis and tunica albuginea. For, as we have seen that the same surface of the vaginal coat is contiguous to the surface of the testicle (viz. the albuginea) as that of the peritonæum, which is contiguous to the viscera of the belly; and as it has the same exudation, so it has the same disease, viz. a collection of water, from the absorption being disproportionate to the exudation. When the tunica vaginalis is distended with the water of a hydrocele, the testicle is towards the back part of the scrotum: it can be felt there; and when the scrotum is placed betwixt the candle and the eye, we see the transparent sac on the fore part of the tumour, the opaque mass of the testicle behind: generally the distended vaginal coat stretches up before the cord conically, thus:—

SIXTH PLAN OF THE TESTICLE.

A, the penis; it is generally corrugated thus, in consequence of the distention of the scrotum in scrotal hernia and hydrocele: B, the scrotum: C, the testicle, covered only by the tunica albuginea: D, the cellular membrane of the cord: E, the tunica vaginalis, distended with the water of hydrocele, and consequently separated from the surface of the testicle: F, that part of the sac of the vaginal coat, which often extends co-

nically before the cellular membrane of the cord D. Now we see that the distention of the vaginal coat does not open up the old communication with the belly; but that, the former communication being shut; and the peritonæum there degenerated into the cellular membrane of the cord, the hydrocele is a distinct sac, surrounding the testicle, and formed of the tunica vaginalis.

To understand this subject of the coats of the testicle, it is not necessary merely to consider the descent of the testicle; but the student must consider it in every point of view, turn it, as it were, into every variety of posture, without which his difficulties will perpetually return upon him. It is for this reason that I have endeavoured to represent the various states of the coats of the testicle in disease.

I have here used the terms *tunica vaginalis*, and *tunica albuginea*, as my reader will find them interpreted in our best old authors. But we may now enquire a little farther.

When we dissect the coats of the adult testicle, we can follow the tunica vaginalis over the surface of the testicle, and by dissecting, separate it from the testicle, leaving that body covered by a dense membrane. Specimens may be seen in my Collection, where hydatids, forming betwixt these membranes, have separated them in a manner still more satisfactory than can be done by dissection. What terms are we to use for these three membranes? 1. *tunica vaginalis*; 2. *tunica vaginalis reflexa*; and, 3. *tunica propria testis*.*

OF THE VESSELS OF THE CORD AND TESTICLE.

In attending to the descent of the testicle, we have a clue also to the vascular system. If we did not know that the testicles were originally placed in the loins

* *De Graaff* speaks of the division of the tunica albuginea into two membranes, probably meaning to distinguish the cellular tissue of the body of the testicle from the investing membrane. *Morgagni*, in his commentary on him, tells us he can separate the tunica albuginea into two laminæ, the inner of which is the most delicate. Advers. An. iv. Animad. i.

within the belly, we might wonder at the length and origin of the spermatic vessels.

The SPERMATIC ARTERY rises on one side from the fore part of the aorta, below the emulgent artery, and on the other from the emulgent artery, sometimes they arise from the arteries of the renal capsule; sometimes there are two spermatic arteries to one testicle. This artery, which the cord receives from the aorta or emulgent, is called the superior spermatic artery, because there is another which rises from the hypogastric artery: this branch runs upward, connected to the vas deferens, as it rises out of the pelvis. Another artery is given to the membranes of the testicle from the epigastric artery.

These arteries, taking their course under the peritonæum, join the fasciculus forming the cord, and supply the cord, and send twigs to the investing peritonæum; they then pass through the abdominal ring, and in their course they are beautifully tortuous.

The VEINS of the testicle terminate on the right side in the trunk of the cava, a little below the emulgent vein, and in the emulgent vein on the left side. There is also (accompanying the vas deferens) a vein, which joins the internal iliac vein. All these veins, in their course from the testicle, are protected from the column of blood, and from the consequences of compression, by numerous valves. These valves are very strong, and will bear a great column of mercury before they give way or burst. This plexus of convoluted veins of the cord is the most beautiful in the body; and we may observe, that such convolutions of veins are ever attendant on arteries tortuous in their course, and subject to occasional excitement. And further, if by accident there is excited an uncommon action in the arteries of a living body, that action will be apparent from the distended or enlarged state of the veins. In the testicles of such animals as have their seasons, the artery and veins of the testicle become still more convoluted, and form a mass of vessels, which has been called *corpus pyramidale*.*

* Corpus varicosum, — Corpus Pampiniforme; Alias parastatum varicosum; Galen de Semine; Util. partium. — As the old physio-

The nerves of the testicle, like the blood-vessels, come from the loins: they form a division from the emulgent plexus, and are continued down upon the vessels. This connects the testicles to the abdominal viscera, giving them much of the same sympathies. The stomach, intestines, and testicle, sympathise readily with each other.

The lymphatics of the testicle are numerous, and easily demonstrated by blowing up the cellular structure of the body of the testicle; and this has been the ground of dispute between physiologists; and the proofs of some important points in the doctrine of absorption have been drawn from the injection of the lymphatics of the testicle and cord.

The CREMASTER MUSCLE, as we have seen in the first volume, takes its origin from the internal oblique muscle of the abdomen, from the os pubis, and, passing down over the vessels of the cord, is expanded on the tunica vaginalis. The use ascribed to it is to suspend the testicle, and prevent it from dragging upon the vessels of the cord; but it is chiefly useful in compressing the body of the testicle, drawing it up, and accelerating the discharge of semen. A very principal use is to compress the veins of the cord, and to support them against the impulse from within.

Thus we find the cord of the testicle, as it is called, to consist of the excretory duct; of the arteries, veins, and nerves; of the lymphatics returning from the testicle; of the cellular tissue embracing and supporting all these vessels; and, lastly, of the fibres of the cremaster muscle.

OF THE STRUCTURE OF THE TESTICLE.

It is to De Graaff that we owe the knowledge of the structure of the testicle; and indeed the merit of this great anatomist has not been acknowledged with suffi-

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logists saw and observed this wonderful tortuosity, and the tendril-like form of the spermatic artery, they thought that the blood was here begun to be changed into semen, and therefore they called them the *vasa præparantia*.

cient gratitude by modern anatomists: but after the fervour of disputation has subsided, the merit of ingenuity and of discovery must return to him to whom it is due. No one more highly values than I do the improvements of anatomy by the Hunters and Monro; but I must say, that the structure of the testicle was demonstrated by De Graaff to his fellow-anatomists of Montpelier; and his discoveries published in a manner so perfect, as to leave us little to learn from more modern authors.

De Graaff, by exciting the gland of brutes, and tying the spermatic cord, had the seminal vessels distended. He did not depend upon injections: by maceration and dissection in this distended state, he unravelled all the intricacies of their tubes. More modern anatomists have proved the truth of his observations by injections of mercury, and have succeeded in a variety of ways of preparing the testicle.

Tubuli testis. — When the tunica propria testis is lifted, the body of the testicle is found to consist of innumerable delicate white tubes; which, when disentangled from the minute cellular membrane which connects them, and floated in water, exhibit a most astonishing extent of convoluted vessels. By a closer attention, however, to this structure, before it is thrown into confusion by pulling out the tubes, they appear to be regularly laid in partitions of the cellular membrane. These sepimenta are very regular in some animals, and while they separate the seminal tubes, they support and convey the blood-vessels to the secretion of the semen. Dr. Monro has denied the formal divisions which De Graaff had engraved, but admits them less regular, less easily found, and not so limited in their number; nor does he find that they prevent all communication betwixt the tubes of the testicle.

These seminiferous tubes of Haller, or tubuli testis of Monro, run towards the back of the testicle. Each of these tubes seems to be cylindrical, or of one diameter throughout their whole extent: we see no communication betwixt them; no branches given out or

going into them; nor have I been able to distinguish a beginning for the whole, nor for any one of them. There seems to be only one tube wonderfully convoluted and folded up in each subdivision of the testicle.

Rete testis. — When the tubuli come out from the body of the testicle, they run along the back of it, and communicate by inosculations with each other, so as to form a net-work of vessels, from which appearance Haller named them rete testis.

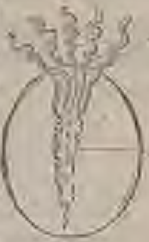
Here it often happens, that the mercury stops,, when it has been injected backwards from the vas deferens; and it is this part which has been better described and drawn, in consequence of mercurial injections, than it was by De Graaff; for he, as we have said, saw this part only filled with semen.

Connected with the rete testis is the corpus Highmorianum.—Where the lines of the membranous septa, and cellular membrane of the testicle, meet on the back of the testicle, and under the epididymis, they form a white line. This white line running along the testicle, was supposed by Highmore to be a hollow tube; it was compared with the salivary duct; it was thought to be a cavity leading from the body of the testicle to the head of the epididymis, and to form the communication by which the semen flowed from the testicle. De Graaff first refuted this notion, and showed that it was not by this one great duct, but by these smaller tubes forming what has been now called the rete testis, that the semen came from the testicle: still it had continued a question, whether this white line was really solid, or a tube; and upon faithful examination of the point it appears, that this is expressly as it was explained by De Graaff, viz. that it is a mere collection of the membranes of the body of the testicle, forming a linea alba; and as the septa are more distinguishable in some animals, so is the corpus Highmorianum. *

Vasa efferentia. — The tubes running on the back of the testicle, and forming the rete testis, we have understood to arise from the tubuli testis; now it is the

* This body is called a mere *firmamentum* or binding. — Winslow.

continuation of the rete testis which is called vasa efferentia. The vasa efferentia are very delicate vessels which run out from the head of the testicle, single at first, but they are soon convoluted, and by these convolutions they are formed into an equal number of *vascular cones*, which constitute the head or larger part of the epididymis. These vasa efferentia and vascular cones are connected by a very delicate cellular membrane; and it is a piece of very nice dissection to display them after they are injected with mercury.*



EPIDIDYMIS.—The vasa efferentia, after forming these conical convolutions, unite, and form larger tubes; these again unite, and form one large excretory duct, the *vas deferens*: and this vessel, being convoluted to a wonderful degree, forms a body, which, being as it were placed upon the testicle, has been called epididymis.

In the substance of the testicle there are no glands nor follicles; the arteries minutely ramify amongst the seminal tubes, and, there is reason to believe, secrete the semen into them. The seminal vessels in the substance of the testicle, or tubuli testes, run together upon the surface of the testicle, and form the rete testis. From the rete testis are continued the vascular cones: these convolute, and, running together, form the epididymis; from which the tube is continued under the name of the vas deferens. It passes up the cord, enters by the ring into the abdomen, and then, passing down into the pelvis, terminates in the vesiculæ seminales, in a manner presently to be explained. It is not likely that the vis a tergo, the power of the arteries, pushes the semen through all this length of tube, of which the epididymis itself is reckoned to be several feet in length, if the various convolutions were undone; such an action on the testicle as that of the dartos or cremaster muscle could give only a general pressure, but could not force on the semen in tubes which take so great a variety of directions. We are therefore left to the supposition, that

* Description of the figure: — A, Rete testis. B, Vascular cones.

these tubes themselves have a power of accelerating the fluids through them.

There is a duct which sometimes arises from the epididymis, and which we find to terminate abruptly in a blind end:—of this, Mr. Hunter speaks in the annexed note. *

OF THE TESTICLE IN GENERAL.

The testicle is of an oval form, and of the size of a pigeon's egg; it is a little flattened on the sides: it hangs in the scrotum by the spermatic cord; one end of the oval, forward and high; see plan seventh, B; while the other is backwards, and drops lower, C. The spermatic cord consists of the artery which brings blood; of the veins which return it; of the vas deferens, which carries the semen to the vesiculæ seminales at the neck of the bladder; of lymphatics, which are essential to the structure of every part. This cord of vessels comes down from the belly, and passes by the ring of the abdominal muscles: it is about four inches in length, and is fixed into the upper and back part of the body of the testicle.

* "By a supernumerary vas deferens, I mean a small duct, which sometimes arises from the epididymis, and passes up the spermatic cord along with the vas deferens, and commonly terminates in a blind end, near to which it is sometimes a little enlarged. I never found this duct go on to the urethra, but, in some instances, have seen it accompany the vas deferens as far as the brim of the pelvis. There is no absolute proof that it is a supernumerary vas deferens; but as we find the ducts of glands in general very subject to singularities, and that there are frequently supernumerary ducts, there being often two ureters to one kidney, sometimes distinct from begining to end, at other times both arising from one pelvis: these ducts arising from the epididymis, I am inclined to believe from analogy, are of a nature similar to the double ureters. They resemble the vas deferens, as being continuations of some of the tubes of the epididymis, are convoluted where they come off from it, and afterwards become a straight canal passing along with it for some way, when they are commonly obliterated.

"The idea of their being for the purpose of returning the superfluous semen to the circulation is certainly erroneous, from their being so seldom met with, and so very seldom continued further than the brim of the pelvis." Many examples of this may be seen in my Collection.

The body of the testicle is easily distinguished, and is the place where the secretion is performed. It is strictly the body of the gland, while the part above it is only the duct by which its fluid is discharged.

The ancients called the testicles didymi, gemini, twins; they, therefore, called that part which is laid on the back of the testicle epididymis, as added to it. To the surgeon, it is essentially necessary to attend to the relation of the parts of the testicle as felt through the scrotum.

SEVENTH PLAN OF THE TESTICLE.

In this seventh plan, fig. 1., we see the testicle as in its natural situation, covered with its membranes, and appearing like one body; while in the second figure, it being represented freed from its outer coat, we see the epididymis as laid upon the testicle, and consisting of the convoluted tube. First we observe A, the body of the testicle: B, the beginning of the epididymis, or the large head of the epididymis *: then we see it laid along the back of the testicle, and observe C to be the small head of the epididymis †, where the tube is reflected to

* *Globus major*, or head.

† *Globus minor*. This part we often distinguish retaining its hardness after the subsiding of the general swelling of hernia humoralis. From this point we can trace all the connections of the other parts.

re-ascend upon the testicle, and to form D, the vas deferens.

Now, we have to observe, that the point C, fig. 2., or small head of the epididymis, hangs over the testicle, and points backwards to the perinæum, and can be felt through the whole coats; and that the body of the testicle A, is towards us when we examine a patient. — Further, as the letters in figures 1. and 2. refer to the same points, we have only to notice the fainter indication of the parts in fig. 1., it being invested with the coats; and to observe the general relation of the testicle to the scrotum and penis.

There is one other circumstance to be observed, viz. that the epididymis is always laid on the outer side of the insertion of the cord into the testicle; from which we distinguish, with ease, in a preparation, to which side the testicle belongs. Thus, in the annexed plans, the testicle of the left side is represented, which we know from the points C, being directed backward, while the epididymis is laid along the left side of the insertion of the cord.

OF THE VESICULÆ SEMINALES.

Behind the prostate gland, and attached to the lowest part of the urinary bladder, lie two soft bodies, the vesiculæ seminales. They appear like simple bags when seen from without, but dissection shows them to consist of a cellular structure: each of these bodies is about three fingers' breadth in length; their backmost point is large and round, and at the same time that they diverge from each other, their narrow points unite, or are contiguous to each other forwards, and enter at the back part of the base of the prostate gland.

As we have seen, the peritoneum does not descend far enough betwixt the bladder and rectum to cover or invest these vesiculæ; they are therefore involved in the cellular texture, and covered with strong fibres, besides being subject to the compression of the levator ani muscle. When the vesiculæ are cut into, and especially when they are distended, dried, and cut, they ap-

pear cellular; but if they are carefully dissected, they present the appearance of a convoluted duct.

This cellular appearance is produced by the duplication of their inner membrane, together with the distortions and curves of the canal. Their outer surface is covered with a fine membrane, which connects these cellular convolutions.

The vesiculæ are copiously supplied with arteries: their surface is covered with veins and lymphatics. Heister, Winslow, and others, have described small glands seated in their sinuosities; but these are confidently denied by others. These vesiculæ are themselves glands, or, in other words, the arteries secrete into them a peculiar fluid. The fore part of each of the vesiculæ, which we have said sinks into the back part of the prostate gland, runs under the neck of the bladder, and opens by a distinct mouth into the urethra on the surface of the verumontanum.

The connection of the vas deferens with the vesiculæ is very particular: the duct and the extremity of the vesicular tube join, and they together open into the urethra.

There is nothing in the human structure to discountenance the idea that the semen may pass retrograde from the vas deferens into the vesiculæ seminales; but as in some brutes the vas deferens has no connection with the vesiculæ seminales, it is to be presumed that they are not mere receptacles of the secretion of the testicles.

The extremity of the vas deferens joins the duct of the vesiculæ where it is imbedded in the prostate gland: the union of the vas deferens and duct of the vesiculæ is not attended with an enlargement of the duct; on the contrary, as the duct passes forward deep into the substance of the gland to arrive at the urethra, it becomes remarkably narrower until it opens in a very small orifice in the verumontanum. The duct (if we may so call it) of the vesiculæ passes a considerable way into the gland before it terminates in the urethra.

The vesiculæ appear to be useful in adding a fluid to the secretion of the testicle, which being poured together into the sinus of the urethra, are then sufficient to distend this part of the canal, by which the ejaculator muscle is excited, and effect given to its action; for a smaller portion of fluid would not be carried forward by its contraction; unless there were a provision of fluid sufficient to distend the sinus of the urethra, the semen could not be thrown out from the urethra. This supposition is not opposed by the facts stated by Mr. Hunter, that in many animals the vesiculæ and vasa deferentia open by distinct foramina into the urethra, because in that case the fluids of these secreting bags might be equally mingled with the semen in the sinus of the urethra, although they do not flow from the same tube.

VERUMONTANUM.—The verumontanum, or caput gallinaginis, is an eminence on the lower part of the urethra, where it is surrounded by the prostate gland. It is larger and round towards the bladder, and stretches with a narrow neck forwards. On its summit, the two orifices of the seminal vessels open; and around it there are innumerable lesser foramina and mucous follicles, the ducts of the prostate gland.

The SINUS POCULARIS is the sac or large lacuna formed

within the caput gallinaginis; its mouth is directed forwards, so that the urine flowing out of the bladder lays the margin down, and as the seminal orifices open within the margin, they are by this means protected from the urine. Sometimes the ducts are found opening on the sides of the sinus.*

* Mr. Hunter rests his opinion of the vesiculæ not being receptacles of the semen principally on these facts. The fluid contained in them does not resemble the secretion of the testes. Of this he satisfied himself in a man shot by a cannon ball, whom he examined immediately after he expired. A fluid is sometimes emitted in straining at stool, which he considers to be from the vesiculæ. A gentleman could emit semen in the common quantity, immediately after this had escaped. He found in several instances, where one testicle had been extirpated, that the vesicula on the same side was full of its usual fluid. In one subject he found the vesiculæ full, when there were neither perfect vasa deferentia, nor ducts leading to the prostate. The vesiculæ are distended in the weak as well as in the strong; in the old as in the young. In different animals the vesiculæ and the testes vary greatly in their relative sizes. The contents of the vesiculæ are different, while the semen continues the same. In different animals the ducts open unconnected with the vasa deferentia. The fluid in the vesiculæ seminales of the gelding and the stone-horse has the same appearance: these bags are larger in the latter: and the contents are very different from the semen in the stone-horse. Some animals have no vesiculæ. Birds have not got them, and they copulate many times successively, and thus appear to require a receptacle.

That the vesiculæ are in some way subservient to generation, he believes, because, as there are variations in the developement of the testicles, in those animals that have their seasons, so there is a corresponding variation in the developement of the vesiculæ. This is analogous, he thinks, to the diminution and the growth of the prostate gland in the same animals, according to their seasons. The deprivation of the testicle makes various parts concerned immediately in generation shrink, as the penis and its muscles.

He concludes that the bulb of the urethra is the receptacle in which the semen is gathered before emission, and not the vesiculæ; that these are for secreting a peculiar kind of mucus, of which he has not ascertained the use. See Animal Economy.

THE

ANATOMY

OF THE

FEMALE PARTS OF GENERATION.

THE ANATOMY OF THE PARTS IN THE FEMALE PELVIS.

The parts of generation are divided into the external, which are those without the pelvis; and the internal, or the viscera of the pelvis, which lie within the bony circle of the true pelvis.

THE EXTERNAL PARTS OF GENERATION.

The external parts of generation are the mons veneris, labia, clitoris, nymphæ, urethra, hymen, and carunculæ myrtiformes. Upon these subjects we have no want of books and information; for accoucheurs of the old school dwelt upon the description with particular accuracy. These parts were within their ken, which we cannot say of the viscera of the pelvis; and therefore upon this first head we shall be more brief.

In very young children these external parts bear a large proportion to the body, greater than at any subsequent period before the age of puberty. From the age of two years to twelve or thirteen, there is little increase. At puberty they are suddenly and completely evolved. Preceding menstruation and the developement of the

uterine system, the whole parts, internal and external, partake of a sudden impulse. They become turgid and vascular: the fat is deposited in the surrounding cellular membrane.

About the fortieth year, when the menses disappear, this fulness of the private parts also ceases, and the fat is re-absorbed.

The MONS VENERIS is that prominence on the symphysis pubis, which consists of the skin raised and cushioned up by the fat inclosed in the cellular membrane. There is a great variety in its size. In early life it is small: it becomes, as we have said, more prominent at the age of puberty: in fat women it is of an enormous size; and in some warm climates a particular laxity prevails. From the hair on this part, marking the age of puberty, it is called pubes. As the lax texture admits of distention with the fluid of anasarca, it is sometimes from this cause very greatly swelled.

The LABIA.—These are often named alæ, from a slight resemblance to wings, and they are also called alæ externæ, magnæ, or majores, from their place, and from their superiority in size over the nymphæ. The labia seem to be the mons veneris continued downward and laterally, until meeting below, they complete the circle of the vulva; at their lower angle by their union they form the fourchette, or frænum labiorum. The structure of the labia is similar to that of the mons veneris: sometimes one is larger than the other.

The great sensibility of the membrane which lines the inside of the labia requires some defence, and therefore the whole surface is amply supplied with mucous follicles and glands. The labia are a protection to the other soft parts. If the clitoris or nymphæ project beyond them, they are subject to violent inflammation.

The parts here have either such folds, or are of so lax a texture, as to permit a great degree of distention during the passage of the child. But as the labia have no muscular power, and depend entirely on their elasticity for restoring them to their original size, they commonly, after being very much dilated, remain in some degree larger and more lax. It is different with muscular parts,

as the orificium externum, which, by the power of its sphincter, is restored after labour to its original size. In man, hernia descends from the abdominal ring into the scrotum; but, in woman, when there is a rupture from the ring (which is rare), it falls into the labium.

The NYMPHÆ are named labia vel alæ minores, or labia interna, to distinguish them from the great labia. They are like a miniature representation of the great labia: they are covered with a very delicate membrane, and have great sensibility. They begin immediately under the glans clitoridis, and seem to be only an extension of its præputium, formed by a folding of the membrane. Their size varies much. They commonly stretch downward and backward to the middle of the orifice of the vagina; sometimes no further than to that of the orificium urethræ, and in a few instances they extend even in the length of the fourchette.* They are very vascular, and have somewhat of a cellular structure, and thus partake of a degree of turgidity, in consequence of irritation and vascular action. The most modest of the uses ascribed to them is, that of directing the stream of urine. As they are obliterated during the passage of the child's head through the vulva, it is probable that they facilitate the necessary dilatation.

The nymphæ are, in their natural situation, covered and completely protected by the labia externa. When naturally large or increased by disease, or in a very relaxed state, they are deprived of this covering: they project from under the labia, and are apt to become inflamed, and even to ulcerate. The original disease, or tumour, is augmented, or they become, perhaps, hard and callous. In children they bear a very great proportion to the other parts, and are more conspicuous and prominent than in the adult. When enlarged by disease they sometimes require to be extirpated; in which operation, as they are very vascular, and as with their growth their blood-vessels enlarge, considerable hæmorrhage may be expected.

* Both Riolin and Morgagni have seen the parts without the nymphæ.

The CLITORIS is similar to the male penis. Like the penis, it consists of cells for receiving blood; and in a similar manner, it arises from or takes hold of the rami of the os pubis by two crura: these unite at the symphysis pubis, to form the body of the clitoris, which is suspended from the os pubis, like the penis, by a kind of ligament. The clitoris has also a kind of glans, over which the integuments make a fold like a præputium. In short, it has the same sensibilities, the same power of erection with the membrum virile; only it has no urethra nor spongy body, like that of the urethra of man, and is so small as to be hid within the labia.

The stories of the increase of this, even to its pre-eminence in size over the penis, are very idle. It is not wonderful that a clitoris of such magnitude should suggest the idea of a hermaphrodite, or person partaking equally of the distinguishing attributes of either sex.

OF THE URETHRA.

The urethra of the female is short, straight, and wide; its length an inch and a half, or two inches: its direction nearly straight, or only slightly bending under the os pubis; and its diameter such as will admit a catheter the size of a writing quill. The consequences of these peculiarities are, that the catheter is easily passed when there is no very unusual obstruction; that women are not so much exposed to the disease of stone in the bladder as men; for though this is much owing to constitutional peculiarities, yet it is obvious, that when a small stone is formed, and passes into the bladder, it is more easily discharged in this sex. If it does not pass with the gush of urine, yet the canal can be dilated, so that a very considerable calculus may be discharged without incision.

The opening of the urethra is in a direct line under, or behind, the clitoris, and about an inch from it; it is in the middle of a slight prominence, and its vicinity is plentifully supplied with mucous glands. If the relation of the orifice to the clitoris be observed, there is, in the natural state of the parts, no difficulty in slipping

the point of the catheter, on the end of the middle finger, from the clitoris, until it is caught upon the lacuna-like orifice of the urethra.

From the length and sudden turns of the male urethra, from the double function it performs, and from its being embraced by the prostate gland, the obstructions of the urine are more frequent, and the catheter less easily passed, than in woman. The catheter, too, requires to be of a very peculiar form. The short and wide urethra of woman requires only a simple and almost straight tube; and although accurately to adapt it to the course of the urethra a considerable curve might be given to it, yet that is not necessary in common cases; and circumstances will occur to the accoucheur which will preclude the possibility of using such an instrument.

We shall only mention here such cases of obstruction of urine as are in a particular manner illustrated by the anatomy and connection of the parts. These are tumours of the ovarium, tumours of the womb, polypi, distention of the vagina, displacement of the womb, as procidentia, prolapsus, retroversio, &c.; and, lastly, the child's head, in labour.

The ovarium being enlarged, and falling down into the pelvis, either presses upon the neck of the bladder, causing obstructions, or pressing and weighing on the fundus of the bladder, it occasions a stillicidium urinæ.

Tumours of the womb, especially of the neck or orifice, as it is in contact with the urethra, very soon affect this organ. Thus, I have seen a cancer of the orifice of the womb, by exciting inflammation in all the surrounding parts, and by massing them together into a tumour filling the pelvis, occasion obstinate obstruction of urine.

Polypi attached to the orifice of the womb, and filling the vagina, produce the same effect. In all such cases, perhaps, the tumour may be pushed up, so as to permit the flow of urine, or the introduction of the catheter.

A case occurred to Mr. John Bell, in which the tumour of the womb compressed the neck of the bladder. A catheter was passed, and gave instant relief. The

midwife, after some time, came, and said, that the catheter would not pass. He found that he could pass the catheter into the bladder, but no urine flowed; and it was discovered, that the tumour, increasing backward, came to press upon the ureters, so as completely to obstruct them where they enter the bladder. The woman unavoidably died; each kidney and ureter was found to contain four or five ounces of urine.

A slight sketch of the parts in the female pelvis will, perhaps, better explain the connections of the neck of the bladder than any description, and will certainly better illustrate the cause of some kinds of obstruction, particularly that arising from the change in the posture of the womb.

FIRST PLAN OF THE FEMALE PELVIS.

A, the os pubis cut through: B, the spine and sacrum also cut directly down: C, the urinary bladder moderately distended, and rising behind the pubes: D, the urethra, very short, and taking a gentle curve under the symphysis of the os pubis: E, the womb: G, the vagina: the os tincæ, or orifice of the womb, is seen projecting into it: H, the rectum.

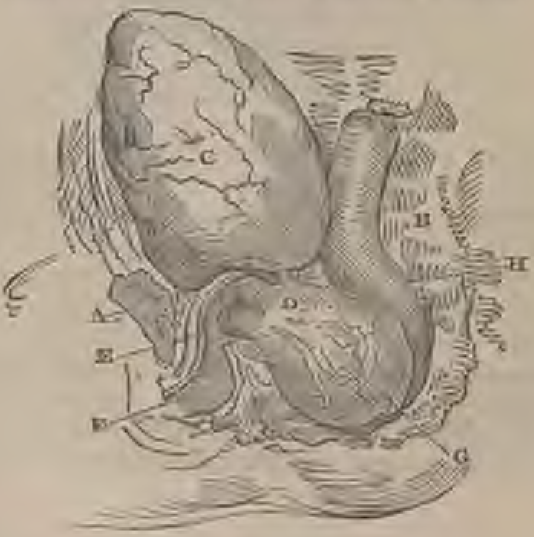
Prolapsus, or falling down of the womb, is frequent with those who have borne many children. By this slipping down of the body of the womb E, into the vagina G, it presses on the neck of the bladder, or

urethra. This is also apt to happen in the first months of pregnancy, from a degree of difficulty which the womb in its enlargement has in rising above the brim of the pelvis.

We may observe also from the place of the vagina G, that its diseases, its scirrhous hardening, its distention by the menses, will also compress the urethra and neck of the bladder.

The retroversion of the womb is the most formidable obstruction to the urethra. It is produced by distention of the bladder acting on the womb in a particular situation, and is the cause of suppression of the urine. When the womb in the third or fourth month of gestation has increased so much as to produce a degree of compression on the surrounding parts, and to rise above the brim, and shoot up into the abdomen, a distention of the bladder is apt to throw the fundus under the projection of the sacrum. We have to observe the connection betwixt the back and lower part of the vagina. By the distention of the bladder, the vagina is stretched, and the orifice of the womb is raised, which throws back the fundus of the womb, so that this comes to be the situation of the parts.

SECOND PLAN OF THE FEMALE PELVIS.



A, the os pubis: B, the sacrum: C, the bladder of urine much distended, and rising above the pubes: D, the connection betwixt the back part of the bladder and the upper part of the vagina, and through which the rising of this part of the bladder (in consequence of its distention) has drawn up the orifice of the womb, and thrown back the fundus: E, the orifice of the womb, which, being raised and turned up, no longer presents so as to be felt by the finger in the vagina. It will be observed, also, that the womb now lying across the pelvis, this lower part is forced against the neck of the urethra, so as to compress it, and cause total obstruction of urine. F, the vagina, which is stretched in consequence of the rising and turning up of the orifice of the womb: G, the fundus of the womb enlarged and distended by impregnation, fallen back under the promontory of the sacrum, and compressing the rectum H.

Now, when the fundus of the womb is thrust back, and the orifice raised by the distention and consequent rising of the bladder, the natural and simple cure is to introduce the catheter, and draw off the urine. But should this not be done at first, then there being distention of the bladder, and pressure on the rectum, the abdominal muscles sympathise with these parts, so that bearing-down efforts are made, and the fundus of the womb is forced further down into the hollow of the sacrum, while the orifice is directed upward.*

Were this distention to happen at any other time than just when the uterus is of such a size, that being thrown back, it catches under the sacrum, and does not rise again, no harm could follow. — I attended a woman afflicted with obstruction of urine, who died. I afterwards opened the body, and found that the womb, being enlarged by disease, had produced much the same effect as if it had been enlarged by pregnancy, viz. obstruction of the urethra; for the body of the womb had fallen into the hollow of the sacrum, and had formed adhesions there with the rectum, while the orifice of the womb

* See a prepartion in my Collection, with the accompanying drawing and model. Cases by Dr. Wm. Hunter, in the Medical Observations and Enquiries.

pressed forward upon the os pubis, so as to produce an obstruction of the urine. The parts were otherwise diseased, but this was the cause of the fatal termination of the complaint.

As we treat of those subjects only as connected with the urethra, we may observe, that sometimes the urethra takes a course not round behind the os pubis simply, nor straight upwards, but curved backwards, so that the convexity of the catheter requires to be towards the sacrum, to allow the point to pass over the orifice of the womb, or perhaps the flexible or the male cathether may be required.

The effect of the wedging of the child's head in a tedious labour is to elongate and compress the urethra in a very particular manner. Many young men have felt the difficulty of introducing the catheter in this case. But it is a difficulty proceeding generally from ignorance or inattention. I believe there never occurs a case in which the child's head is so firmly impacted, that the catheter cannot be passed; but often practitioners forget the direction which the urethra necessarily assumes, when the child's head has sunk into the pelvis.

Orificium vaginæ. — This is also named orificium externum, in distinction to the uterine orifice. I notice it under the head of the external parts, because we have to speak of the parts which surround the orifice, as the hymen.

All anterior or external to the orifice of the vagina and within the labia is the vestibulum. The orifice of the vagina of the human female is abridged by the hymen, which is a peculiar membrane. It is of a semilunar form, and sometimes surrounds the lower part of the orifice of the vagina; — commonly it surrounds only the lower half of the circle, though it would seem to vary considerably in shape, place, and strength. It has been found surrounding the whole circle of the orifice, leaving only a small hole in the centre or upper part; or it is described as perforated with lesser holes, allowing the evacuation of the menstrual blood. In other cases, it has been found a complete septum, preventing the evacuation of the menstrual blood. This

is a fact which I do not dispute, for I know that the perforation for the evacuation of the menstrual blood is sometimes necessary.* When I have seen the imperforated vagina in the child, it was not the hymen which closed the orifice, but an adhesion of its sides; yet this adhesion, if it had come to be distended with the menstrual blood of several periods, would have presented the appearance of a tense membrane stretched across the orifice.

Such semilunar membrane as I have described will occasionally be seen in the female parts; but it has such an appearance as may easily be destroyed in the preparation of the parts, if the anatomist be inattentive or careless. It is neither a guard, nor is its existence a test of female chastity. Often in tender children there is no such thing to be seen; while, on the other hand, it has been cut to admit of labour and delivery.† Either of these facts is sufficient proof of the idle notions entertained concerning this membrane, and that when present it is, like a contracted præputium in the other sex, a defect.

The CARUNCULÆ MYRTIFORMES — are small and irregular tumours at the back, or lower part of the external orifice: they are seated rather at the sides than exactly at the back part: they are supposed to be the ruins of the hymen, which being lacerated, shrinks into two or three tumours on each side. Some have said, that these exist originally joined together by a thin membrane, or delicate tissue of small vessels, the rupture of which causes an effusion of blood. They seem to be simply corrugations of the inner membrane, which serve as a provision for the dilatation of the parts; and they accordingly disappear during the passing of the child's head.

The FOSSA NAVICULARIS is a sinus, supposed to be of the shape of a boat, whence its name. It is formed be-

* See a case by Mr. Tynney, in Duncan's Med. Comment. vol. iii.

† I need not say how unnecessary and improper such operations are. All rigidity, callosities, even tumours, and undoubtedly the hymen, will yield to that general relaxation of all the parts, which takes place upon the commencement of labour.

twixt the proper orifice of the vagina and the fourchette, or joining of the labia at their lower edge. It is more conspicuous in young subjects.

From the meeting of the labia below, the PERINÆUM commences: it includes the space from the frænum to the anus.

OF THE PARTS CONTAINED WITHIN THE FEMALE PELVIS.

THESE parts are the bladder of urine, the vagina, the womb, the ovaria. We shall consider them under distinct sections.

OF THE BLADDER OF URINE.

As the coats of the bladder of urine in woman do not vary from those of the male bladder, we have under this head only to notice the peculiarities in its relative situation. It is seated behind the os pubis, and betwixt it and the womb; and, on its lower part, it is attached to the vagina: upon the neck of the bladder, or the beginning of the urethra, there is not a body like the prostate gland; and as we have seen, the urethra is short, wide, and straight, and simple in its use.

Women are not subject to calculi, and the operation for the stone is rare in them; for, as already observed, when the nucleus is formed, or when a stone slips down from the pelvis of the kidney, it passes from the bladder with much greater facility than in the male parts. The urethra, of itself, has been known to dilate so as to allow very large stones to pass, or it has been artificially dilated. Indeed, the old operation for lithotomy was rudely to dilate, or rather tear, the urethra; and the modern operation is simply to thrust the gorget along the grooved staff, so as to lay open the side of the urethra and neck of the bladder, by an incision above the vagina. Sometimes nature has effected her own relief by the stone working from the neck of the bladder into

the vagina. A woman had, for a very long period, suffered great distress, not only frequent desire to make urine, and the urine turbid and bloody, but all the usual symptoms of stone violently aggravated: she was delicate and timid, and concealed her distress, until the urine had run for some time by the vagina. After she had been exhausted by long suffering, her friends insisted that she should allow an examination, when a stone was found partly in the bladder, with one of the rough ends projecting into the vagina. The opening was enlarged, and the stone extracted.

We must, in all cases, recollect the connection of the upper part of the vagina and orifice of the womb, with the back part of the bladder. We have seen its effects in producing retroversio uteri. We must also attend to this connection, as tending to the displacement of the bladder in the procidentia uteri. The uterus sinking into the vagina, and the upper part of the vagina being at the same time reflected into the lower part, pulls down the bladder with it, and when (the disease increasing) the womb covered by the vagina comes to hang from the external parts, it has happened that the bladder has sunk down and lain upon the fore part of the tumour, but of course within the everted vagina.

OF THE VAGINA; OF ITS SHAPE, CONNECTIONS, ETC.

The vagina is a tube stretching from the external orifice to the orifice of the womb. Its orifice is bounded below by the fourchette; above by the arch of the pubis; and directly over it, or sometimes within it, is the orifice of the urethra; below, are the carunculæ myrtiformes. It is surrounded by fasciculi of fibres, which are called the sphincter muscle. The canal of the vagina is of a conical form. At the outer orifice it is constricted by the sphincter muscle; but it is wider within, where it receives the orifice of the womb. It may be distended to almost any degree, but naturally its sides, by their own elasticity, the fulness of the veins which are upon it, and the contraction of the surrounding fibres, are in contact.

In the natural state, the orifices of the vagina and womb are but three or four inches distant, often only two; and sometimes, where there is a degree of relaxation, they are nearly in contact. In the first months of pregnancy, the orifice of the womb is kept down by the degree of difficulty the body of the womb has in shooting up from the brim of the pelvis. But the gravid uterus, rising above the pelvis in the latter months, draws up the orifice of the womb, and stretches the vagina.

The vagina bends gently round the pubis, or follows the axis of the pelvis; and as the interior of two circles cut off by the same radii is the shorter, the vagina is longer behind than before.

And thus (*in this plan*) the fore part of the vagina A, is shorter than the back part B. We may observe from this plan, also, that the orifice of the womb C, projects as it were into the vagina, so that the finger touches the os tincæ, and chiefly its anterior lip, without reaching the upper part of the vagina.

The vagina takes its curve nearly in the centre of the pelvis; it is of necessity attached by cellular substance to the rectum and bladder. The urethra, as we have said, opens above the orifice, and that canal is attached to the vagina in its whole length, the neck of the bladder being attached to its upper part. In consequence of this natural connection, disease of the vagina sometimes throws the whole parts, the rectum, vagina, and bladder, into one fistulous ulcer.

The vagina has three coats; that is to say, it has the inner coat, a few muscular fibres dispersed around it, and exteriorly a condensation of the surrounding cellular membrane, which may be considered as the third coat.

The internal, or villous coat, is a reflection of the delicate covering of the external parts. It is of larger extent, or longer than the others; and is therefore tucked up into rugæ, which run across the vagina. They are more remarkable on the fore and back part of the vagina; they are less in married women, and considerably obliterated by repeated labours.

To supply a viscous secretion for the defence of this surface, there are mucous glands irregularly scattered over it, and they are particularly numerous at the orifice.

The muscular coat is not very strong, nor are the fibres distinct, from which some have doubted their existence, alleging, that there is here only condensed cellular membrane, and that the contraction of the vagina is the effect of mere elasticity. I observe so great a profusion of venous vascularity, that I presume the vagina suffers an inflation of its coats, and, consequently, contraction from an afflux of blood to it. The muscular fibres are, however, as we have said, gathered into fasciculi near the orifice, so as to be distinctly visible.

The firmness in the structure of the vagina supports the womb: the dilatation of the vagina, the relaxation which old age, and frequent labours produce, occasion the falling down of the womb. It is a disease almost peculiar to those who have borne many children, to the old, weak, and relaxed, and to those who are subject to the fluor albus; every flux from the womb, or discharge from the vagina, having a remarkable effect in relaxing the parts.

This, from the nature of the parts, must be an increasing disease; for no sooner has the womb fallen down into the vagina than it becomes a source of irritation, excites a bearing-down pain like tenesmus, an uneasy sensation, a desire to make urine, and an obstruction of urine; all which is explained by the connection of the parts. The womb lodging in the vagina dilates the orifice, and presses long on the perinæum; at last it is entirely forced out, and the prolapsus uteri becomes the procidentia uteri; it is, in truth, a hernia of the womb.

The third and outer coat, as we have said, is formed of the cellular membrane, by which it is connected with the surrounding parts; but the peritonæum comes down upon the higher part of the vagina. This is the reason why a portion of the intestine, when it slips down betwixt the vagina and rectum, forms a kind of hernial tumour in the vagina, and it explains how the water of ascites has pushed down the back of the vagina, so as to be felt externally; indeed, the water of dropsy has been drawn off by puncturing here.

For the greater space, however, the outer cellular coat of the vagina connects it with the urethra on the fore part, and with the rectum behind. From which close connection of parts, we see the consequence of the delay of the child's head in the second stage of labour, that the head lies violently distending, and compressing the parts, while the woman, exhausted by the previous stage, is unable to complete the delivery. From violent inflammation, with a deficiency of secretion, there arises a cold and flabby state of the parts. When the woman is delivered, the parts have suffered so much, that they slough off; sometimes the urethra is laid open on the fore part, and sometimes the rectum behind.

OF THE UTERUS.

The uterus, or womb, is a firm vascular body of the size of a pear, and in shape not unlike what you may conceive of a flattened pear. At its upper and lateral parts it terminates in the Fallopian tubes; and the os tincæ, or lower part, projects into the vagina. We must, for the convenience of description, distinguish it into these parts: — The upper part is called FUNDUS: it is the part above the going off of the Fallopian tubes. The BODY of the uterus, which is the larger part betwixt the fundus and the narrow neck: the CERVIX is the narrow neck; and the OS TINCÆ, or orifice, is the lower part, formed of bulging lips, which project into the vagina: over this part the inner membrane of the vagina is reflected. We distinguish also the two surfaces, for the womb is of a flattened form. The ante-

rior surface of the body of the womb is convex, but the posterior surface is considerably more convex than the anterior, and even during gestation it keeps this relative figure.

The whole size of the uterus is about three inches in length, and two in breadth, but there is a very great variety in this respect, from age, the effect of pregnancies, and other causes. When, in its usual situations and relations, the fundus is on a level with the brim of the pelvis, or a very little below it. In the fœtus, the womb is like the bladder, considerably above the brim of the pelvis; but in a few weeks, the pelvis enlarging, it sinks deeper, and soon assumes the same situation as in the adult.

Fallopian tubes.—From the lateral obtuse angles formed betwixt the fundus and the body of the uterus, the Fallopian tubes are continued. These tubes may almost be considered as a continuation of the uterus, did we not find them so very distinct in their substance. They are about three inches in length, take a tortuous course, and their extremities have an unequal, fringed termination, which is called the fimbriæ.* Their canal is very small towards the uterus, but enlarges; and is open towards the extremity. These canals are the communications by which the ovum formed in the ovarium is carried down into the womb.

Ligaments of the uterus.—The uses ascribed to the ligaments have been to support the uterus from sinking too deep into the pelvis, and to steady it, and direct it in its ascent during pregnancy. But whatever good they may do in the latter operation, they are certainly unfit for the former.

There are four ligaments of the uterus.

The broad ligament of the uterus is formed of the peritonæum; for this membrane, passing down before the rectum, and ascending again, and covering the neck, body, and fundus of the womb, descends on the fore part, so as to reach the vagina before it rises over the bladder. Thus it invests the womb as it does the

* Morsus diaboli.

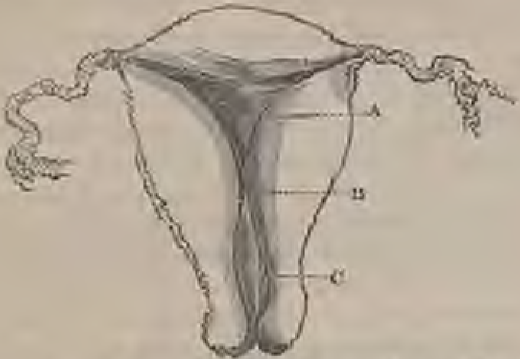
abdominal viscera. This investing of the womb with the peritonæum is indeed a provision for its becoming an abdominal viscus, for in pregnancy it rises out of the pelvis, and, being distended before the bowels, assumes, in every respect, that relation to the peritonæum which they have.

As the womb is included betwixt the duplicature of the peritonæum, it is this peritonæal coat which is continued off laterally, and forms the broad ligament of the womb. This duplicature of the peritonæum, forming a fine membrane, has sometimes had the name of ALÆ VESPERTILIONIS: it is, in truth, like a mesentery to the womb and Fallopian tubes, and serves equally to support and convey the vessels to them. The womb and these two ligaments make a complete partition, running across the pelvis.

From the side of the uterus, a little below, and before the going off of the Fallopian tubes, the ROUND LIGAMENTS arise. They are not merely condensed and elastic cellular membrane; but are composed of fibres with an intermixture of blood-vessels, so that whilst they keep a degree of tension on the uterus, they yield and grow not only in length, but in thickness and strength, as the uterus ascends in the advanced pregnancy: they pass through the abdominal ring, and are attached to the cellular membrane of the top of the thigh. In the gravid uterus, both the broad and the round ligaments considerably alter their position, appearing to rise lower and more forward from the womb than in the unimpregnated state. This is a consequence of the greater increase of the fundus of the womb, in proportion to the lower part of it.

What I have here described, and which are commonly called the round ligaments of the uterus, are the tendons of the muscles, and have a very particular use which authors have not observed: at their upper extremity they terminate in a muscular coat, which is spread over the fundus of the uterus, diverging from the tendon. The use of these tendons is to move the uterus in the first approach of labour, and to present the orifice of the uterus to the axis of the pelvis.

OF THE CAVITY OF THE UTERUS.



The cavity of the uterus is properly confined to the fundus and body, for in the cervix it is more like a canal, and differs essentially from the proper cavity. A, *the cavity of the uterus*; B, *the continued cavity*, where it is very narrow towards the cervix; C, *the canal of the cervix*, where it has an enlargement like a sinus. The Fallopian tubes are seen going off from the cavity of the uterus. These angles of the cavity admit no more than a hog's bristle. The third angle, towards the neck, is, of course, considerably larger. The proper triangular cavity of the uterus is lined with a peculiar soft and delicate membrane: it is very vascular, and the vessels either open on the surface naturally, or bursting out, from time to time, pour out the menstrual blood. The canal of the cervix shows a very different surface. We observe a prominent longitudinal line on the fore and back part of it, from which oblique and transverse rugæ go out. The surface is firmer and callous, and less vascular. Betwixt the rugæ there are lacunæ, which throw out a mucilaginous fluid; and towards the orifice we see these larger and sometimes distinct glandular bodies. This peculiar shape of the cavity of the womb, and the hardness and small degree of vascularity of the lower part, is of the most essential importance. The upper part, the proper cavity of the womb, is pre-

pared for the reception and immediate adhesion of the ovum, when it shall have descended through the Fallopian tube; but the long callous cervix is provided, that there may be no adhesion to the lower part of the womb, and that the placenta may not form over the orifice of the womb; for if it should, the most dangerous kind of flooding takes place on the approach of labour, from the opening of the orifice, and the tearing open of the adhesions of the placenta, before the child can be delivered. The length of the cervix, and the glandular structure of the orifice, are also of much importance in sealing up the cavity of the womb after conception, that there may be no longer a communication with the vagina: for this purpose, a viscid tenacious mucus is poured out; but on the approach of labour, with the softening and relaxation of all the soft parts, this adhesion and gluing up of the orifice is dissolved, and a more fluid secretion is poured out.

From the cavity of the womb the MENSTRUAL BLOOD is discharged at certain periods, from the time of puberty to the approach of old age, when the system is no longer capable of giving nourishment to the fœtus.

It was long disputed from what source the menstrual discharge flowed. Some affirmed, that it must flow from the vagina, and not from the womb, because it flowed sometimes during gestation. This is a fact which cannot be denied. I have attended a patient who menstruated during the entire period or to the eighth month; and I have often observed ladies to menstruate at the first period after conception. On the other hand, we have every proof of the discharge being from the orifice of the womb. For instance, some have observed on dissection of the parts of women dying during the flow of menses, that blood was effused under the delicate membrane of the cavity of the womb. The vessels there have been observed particularly turgid, or the whole surface of the proper cavity, and especially the fundus, spotted with bloody effusions. More particular observation has shown not only the mark of blood poured out from the inner surface, but that the whole substance of the womb

was become thick, soft, and vascular *; and M. Littre affirms, that in the body of a woman who had died during menstruation, and with a conception in the Fallopian tube, he found a layer of red coagulated blood; upon removing which he saw a number of small foramina which admitted bristles. †

But the best and least equivocal proof is that which has been repeatedly observed in the inversion of the womb, when the inner surface has been turned out after labour, and has remained thus inverted, and protruding from the external parts; for then the menstrual blood has been seen to distil from the surface of the cavity of the uterus. ‡

OF THE BLOOD-VESSELS OF THE WOMB.

There are four large arteries which supply the system of the womb, and four large veins which return the blood.

The SPERMATIC ARTERIES come down from the aorta itself, or from the renal or capsular arteries. The spermatic artery taking a waving direction, becomes tortuous in a most remarkable degree as it approaches the uterus: it is distributed to the Fallopian tube, and ovarium, but chiefly to the body and fundus of the uterus, where it forms remarkable anastomoses with the artery of the other side.

The LOWER ARTERY,—the UTERINE ARTERY, comes in general from the hypogastric artery, takes also a serpentine course, and is distributed to the vagina, and the lower part of the uterus, and inosculates largely with

* The authorities upon this subject are Spigelius, Morgagni, M. Littre, Moriceau, Winslow, Sympson.

† This might have been an early abortion, or, perhaps, the decidua, which, it is said, is sometimes formed at the menstrual period.

‡ See Mr. Hill's case in Duncan's Med. Comment, vol. iv. The patient had prolapsus uteri, and she observed, during menstruation, that the fluid came from the orifice of the os tincæ, while none came from the "bag," by which she meant the everted surface of the vagina. She had afterwards fluor albus, and this fluid came from the surface of the vagina. When she had ceased menstruating, the orifice of the womb skinned over.

the other vessels, both in the uterus, and by particular branches on the side of the uterus.

In the first place, it appears, that this copious supply of vessels to the uterus, from four different sources, is a provision that the womb and secundines shall not by any accident of position, or by the progress of labour and the consequent compression of one or both the lower vessels, be deprived of their due supply of blood. Again, their tortuous forms give proof of their occasional greater activity, that they admit of a peculiar and local action during menstruation, and that the blood will move more languidly when the stimulus of the womb has ceased. It is also a provision for the growth and increase of the womb, and the supply of nourishment to the ovum. And that an increased activity in a part must be supplied by a more tortuous form, as well as an enlargement of the caliber of the vessels, is in a particular manner illustrated by the change which takes place in these vessels during pregnancy. For they become, in a much more remarkable degree, tortuous and enlarged.

The substance of the uterus is said to be spongy and compact, which, though it is a seeming contradiction in words, does yet really convey an idea of the effects of the intertexture of vessels in it. Some have said (as Moriceau), that by pregnancy the womb is distended, and grows thinner: others, that it grows thicker, as Daventer; and others again, as Smellie, assert, that it continues of its natural thickness. These assertions are none of them perfectly correct; for the womb is not distended by the growth of the fœtus and membranes, but grows with them. Again, that the substance of the womb grows in a remarkable degree is true, but still, when distended by the waters in the last months of pregnancy, its walls are thinner than in the unimpregnated state. Thus, when it has been cut in the living body, upon the approach of labour, as in the Cæsarean section, I have observed it not more than a quarter of an inch in thickness, even at the part to which the placenta adhered. When I have dissected the womb, after a tedious labour, the waters discharged, but the head wedged in

the pelvis, I have found it considerably thicker. And, lastly, in the full contraction of the womb, after expelling the fœtus and placenta, (for example, in rupture of the womb, where the child and placenta had been forced amongst the bowels, and the woman soon after died,) I found the walls of the womb more than an inch in thickness.*

OF THE OVARIA.

The OVARIA are two oval bodies, which are suspended in the broad ligament behind, and a little below the Fallopian tubes: while they have an oval figure, they are, at the same time, somewhat flattened. By cutting out the ovaria, the animal loses the power of conceiving, and desire is extinguished: they, therefore, bestow what is essential to generation upon the part of the female. In vague speculations on the subject of generation, they were supposed to prepare a female semen! but more particular examination demonstrates that they consist of vesicles which are ova; but how far incomplete, or in what essential circumstance requiring the approach of the male, is not determined.

When we hold the section of the ovarium betwixt the eye and the light, we see a great many pellucid vesicles; and if we examine the ovarium of an animal killed in full health, and particularly in the season, we shall observe these ova to be in all varieties of states of preparation for impregnation. Some small and pellucid, and yet only discernible in the thick outer coat, by having a degree of greater transparency; others which have taken a slight tinge of bloody colour from vessels striking into them; and if the section be made after a minute injection, the vesicles will be seen coloured in the proportion of their maturity; some without a speck of colour; others tinged; one or two loaded with injection; and some vascular, and particularly prominent.

In very young girls, the substance of the ovarium is whitish and very soft; the surrounding membrane is

* See Preparations in my Collection.

thick; and the round corpuscles scarcely discernible; and no irregularities, nor any of those bodies called corpora lutea, are to be seen on the surface. But as the girl advances in years, the little vesicles begin to appear, and when about ten years of age, or just before menstruation, the ovarium is full of ova of various sizes, and some of them more matured, and forming an eminence upon the surface. In the adult woman, the substance of the ovarium, which appeared as an uniform homogeneous mass in the fœtus, is become a cellular and vascular bed, giving nourishment to those numerous vesicles or ova. Before impregnation can take place, there must be a certain state of preparation of the ovaria, without which the approach of the male effects no change in the uterine system. The lower animals having their seasons, and these seasons being a state of preparation for the male, impregnation follows the copulation with much certainty; in women, such a periodical revolution in their system, and instinctive desires, would but ill accord with that superiority in attributes of the mind, which distinguish us in the scale of beings. But women also suffer such an occasional excitement in the uterine system, though unaccompanied with desire, which preserves the womb in a state of preparation for the reception of the ovum, and the ovaria in a state of preparation for impregnation. This is the effect of menstruation.

OF PUBERTY.

Authors have long, with many expressions of surprise, laboured to assign a cause, or frame a theory for the explanation of those changes which we observe in woman at the age of puberty; and, generally, in their theories, they have connected with these changes the monthly and periodical discharges of blood from the uterus, which commences with puberty. These theories have been founded, in general, on principles remote from the laws of a living system. At this period of puberty the whole frame is expanded into the fulness of feminine beauty: the breasts rapidly increase, and are matured; the parts of generation are enlarged; the hair of the

pubes grows, and the menses flow. In explanation of these changes, theoretical conjectures, after this model, have been entertained : — "About this time the growth of the body begins considerably to diminish, and the blood finding easy admittance into the completed viscera, is prepared in greater quantity, the appetite being now very sharp in both sexes, a plethora consequently follows. In the male it vents itself frequently by the nose, from the exhaling vessels of the pituitary membrane being dilated, &c. ; and now the semen first begins to be secreted, and the beard to grow. But, in the female, the same plethora finds a more easy vent downwards, being that way directed, partly by the weight of the blood itself, to the uterine vessels, now much enlarged, of a soft fleecy fabric, seated in a loose hollow part, with a great deal of cellular fabric interspersed, which is very yielding and succulent, as we observe in the womb : for these causes, the vessels being easily distensible, the blood finds a more easy passage through the very soft fleecy exhaling vessels which open into the cavity of the uterus, as being there less resisted than in its return by the veins, or in taking a course through any other part ; because, in females, we observe the arteries of the head are both smaller in proportion, and of a more firm resisting texture. The return of the same is, therefore, more slow, both because the flexures of the arteries, from the increased afflux of the blood, become more serpentine and fit for retarding the blood's motion *, and likewise, because it now returns with difficulty through the veins. The blood is, therefore, first collected in the vessels of the uterus ; next it is accumulated in the arteries of the loins, and the aorta itself, which, urging on a new torrent of blood, augments the force so far as to discharge the red blood into the serous vessels, which at first transmit an increased quantity of warm mucus, afterwards a reddish-coloured serum, and by suffering a greater distention, they at last emit the red blood itself. The same greater impulse of blood

* I have shown that the tortuous arteries always form a provision for the occasional increase of the action and acceleration of the blood.

determined to the genitals, drives out the hitherto latent hairs, increases the bulk of the clitoris, dilates the cavernous plexus of the vagina, and whets the female appetite to venery," &c.

We cannot have trust in so weak a theory; we cannot believe in this plethora, produced by the diminished growth of the limbs; neither can we believe that congestion and plenitude are produced in the female system from the deficiency of perspiration, from their more lax and weaker solids compared with man, from their indolent and sedentary life; for facts are in direct contradiction. The growth and completed function of parts at this particular age is not to be explained by any theory so partially applicable: during almost every period of life there are similar changes taking place in some one part of the body. Parts lie dormant, and are stationary in their growth, which at a particular and stated age of the animal enlarge and develope themselves by a new and invigorated action. Observe how different the proportions of the fœtus are from those of the adult. We see nature careful to perfect certain parts, as the head and liver, at an early period. We see, during early childhood, how the parts shoot out, and evolve in due proportion. We see parts which were large in the fœtus lose their preponderance: we see others, which served some purpose in the fœtal system, gradually shrink and disappear, because they have no longer the stimulus to action in the circle of connections which take place in the adult system. We find other parts, as the teeth, for example, lying long within the jaw, instead of proceeding with a gradual and continual enlargement, suddenly rising at certain stated periods from their embryo state, and enlarging and pushing up through the gums, when it becomes fit that the child should take more solid food than the mother's milk. So the second set of teeth, in a more particular manner, lie quite stationary in their growth within their little sacs, yet quickly, at stated periods, they increase, the enamel is formed, and they rise above the gum. There is an infinite number of such changes depending upon the same laws of the economy, and not different

from those which control the growth, and direct the shape of parts. They depend upon certain laws of the constitution, which give an excitement to certain parts, at stated periods, and which no theory partially applicable will explain. There is a series in which the parts of an animal body are matured, and a succession in which the functions are brought to maturity; and in the female constitution, there are laws determining an action upon the womb and breasts, and all parts subservient to conception and the nourishment of a fœtus, at that period when the woman is arrived at the age fit to take upon her the part of a mother.

OF MENSTRUATION.

Under this head, I shall confine myself to such a general view of the subject as is necessarily connected with the peculiar functions we are now endeavouring to comprehend.

Menstruation is a state of preparation for conception. When, therefore, the menses flow at the natural periods, and in due quantity, it is a sign that the woman may conceive, and that her system is fit for the support and nourishment of the child. It is a general affection of the system, which has a tendency to relieve itself by a topical action, by the excited action of the uterine system; and this excitement of the uterine system is the end which nature is accomplishing. To explain this, I may be allowed to take a short preliminary view: each particular organ or viscus, whilst it has its connections with the general system, is, in truth, a system within itself, having its peculiar functions, sympathies, and even vascular action, in a certain degree independently.

Were not this, in some measure, the case, we should see no local disease or topical action; and no vascular action could be for a moment stationary and confined to one part. The body would, indeed, be then only one great hydraulic machine. But while the several parts have the property of being excited separately to an accelerated action, they are actuated by remote sym-

pathies, and by these sympathies and relations is the whole system in a great measure supported.

Before menstruation commences, there is a preceding indisposition, and symptoms indicating a constitutional affection. And these complaints are usually more severe in the first than in the subsequent periods. The general revolution in the system begins to accumulate its action towards the womb, and those symptoms usually accompanying uterine irritation show how far it is affected, and in a little time the menses flow. Now, I conceive the flow of the menstrual blood to be, not the end which nature is here labouring to accomplish, but the means of allaying the excited state of the uterine system, after the object is accomplished. It is not the discharge of a few ounces of blood which relieves the system; for drawing blood simply will not do it; but it is the excited action of the uterine system which relieves the general distress, and that topical action has full relief in the menstrual discharge. General and topical plethora are terms which have been of great service in explaining this periodical change in the female system; but the state of mere fulness has little effect either on the constitutional or topical change. Even in the exhausted and debilitated state of the system, when menstruation ceases from the want of energy and power in the vascular system, still there remain the same laws governing the sympathies and relations of the several parts; and, although they are feebly and imperfectly excited, they give rise to accumulated distress at the period in which the menses should flow.

With regard to vicarious hæmorrhage from remote parts of the body, some, whose opinion I greatly value, do not consider them as deviations of the menses. At all events, from what I have seen of such hæmorrhages, (tumours, for example, discharging blood at the menstrual periods,) I would observe, that there is an excitement, throbbing, and distention, previous to the discharge of blood, which confirms me in the notion of the necessity of a counter excitement and action, as well as the discharge of blood, being necessary to make a derivation from the uterine vessels. It is by dissection

alone that we can form a correct opinion regarding the final use of the periodical return of the menses.

By dissection we come to the knowledge of the most essential facts. In the first place, it is found, that the ovaria, and their vessels, partaking of the general excitement of the spermatic arteries, are enlarged, full of blood, and with every sign of increased action. We find, also, that the ova are matured and brought to pullulate, and almost to start from their investing membranes. Unless the ovaria are in this state of preparation, conception cannot take place. In considering this subject of menstruation, the mere circumstance of the discharge of blood has been too much thought of, while the other more essential circumstance, the change upon the ovaria, has been neglected. The end of this periodical excitement is to ripen the ovum, the flow of menstrual blood to allay the excited state of the uterine vessels. Accordingly, if conception should take place, the excitement proceeds, and no flow of secreted blood takes place during the period of gestation.

It is not easy to determine, says Haller, either in this or in any other spontaneous hæmorrhage, from what kind of vessels the blood flows. From the circumstance of the hæmorrhoidal discharge, which certainly is from veins, and from the lochia, which is generally supposed to be a discharge from the venous sinuses of the womb after delivery, we have the argument of analogy, that in menstruation also it is a venous discharge. This opinion is further confirmed from stagnant blood being found in the uterine veins of women dying during the flow of the menses, and orifices being observed larger than could well be supposed to be the extremities of arteries.

It is little probable that spontaneous hæmorrhage proceeds from the rupture of the extreme arteries, because it is the activity of the arteries which causes the hæmorrhage; and because this activity is the exertion of a muscular force, and the exertion of a muscular fibre never is such as to tear the fibre itself. On the other hand, we observe that it is the necessary consequence of an increase of the action of arteries, that the corre-

sponding veins dilate, and seem to suffer a force of distention proportioned to their increased activity. We must not forget that many are of opinion, that the menstrual blood flows from the exhaling arteries. This opinion must rest upon argument, and not facts, unless the assertion of Rauw be taken as proof, that he could distinguish their mouths; or that of Meibomius, who said he introduced bristles into them. That anatomists have introduced bristles into pores, or foramina, it would be ungracious to doubt, but that these were the orifices of exhaling arteries, is difficult to believe. I rather imagine, that there is a provision for this evacuation in pores, or foramina, in the extreme veins on the vascular inner surface of the womb.

From the consideration of the cause of menstruation, as I have conceived it, from the symptoms which precede and accompany it, and from the effect attributable to the menstrual action on the uterine system, we cannot consider it as a mere evacuation of blood, but rather as of the nature of a critical discharge relieving the symptoms which preceded it. With regard to the opinion of its being a secretion, we must first know accurately what is meant by the term. If those who suppose the menstrual blood a secretion, mean only that the blood is changed by the action of the vessels of the womb, I should willingly acquiesce in their opinion; for even during the bleeding from the arm by the lancet, or from a common wound, the blood is altered in the space of the few minutes during which it flows; and before the final stopping of a common hæmorrhage, there is a change in the properties of the effused blood.

When there is an unusual source of irritation in the womb, added to the natural and periodical excitement of the parts, the menses become more profuse, they last for a longer period, the time of their intermission is shortened, and, in the end, from some diseases of the womb, there is a perpetual oozing of the blood, which debilitates the woman, and destroys her constitution, or there is sudden and profuse discharge with coagula, unlike the usual evacuation.

OF THE CHANGE PRODUCED BY THE UNION OF THE SEXES.

In considering those changes produced on the ovaria and womb by impregnation, we must have recourse to analogy in the first instance. By attending to the changes produced in vegetables, and the lower animals, we may be enabled to comprehend some of the changes in the female organs consequent upon conception, which we might not otherwise be enabled to understand.

We see that vegetables propagate their branches in every respect like the parent trunk. We see in the autumn the bud lodged in the axilla of the leaf, and observe it pass through the winter in a kind of dormant state; but when it is influenced by the returning heat of the spring, it shoots out to full maturity. This growth is a natural power of propagation and increase, marked by no very peculiar circumstances, yet bearing a strong analogy to the production of the seed.

In the formation of the fruit of the same tree, we see a more complicated provision for the propagation of the plant. We find that although the seed appears to be formed by the natural growth of the part like the bud, yet before it becomes prolific, and capable of growing, and arriving at maturity, it must be influenced by circumstances similar to the union of the sexes of animals; that its power of reproduction depends upon the reciprocal action betwixt the parts of the same plant, or by the approximation of male and female plants.

Between the formation, maturity, and impregnation of the seed of plants, and those of the ova of animals, there is a close analogy. The seed is formed and matured while attached to the parent plant; but the vessels of the plant having completed this operation, shrink from their connections with the seed, leaving it with its little system of vessels complete, and with a kind of imperfect life, which may be considered as analogous to a dormant state. This imperfect life, or perhaps a state merely capable of being excited into life and motion, continues for the winter season, or for a longer period.

The flower of plants solicits the fluids to the seed, as the influence of the leaf cherishes the bud in the axilla. The pulp of the fruit is probably a provision of the same kind, or when it has fallen, to lay the foundation, by its decay, of a soil suited to the tender plant.

In the seed itself, we have much to admire. We find it incased in a strong husk, or shell, which is in general provided with a porous part ready to imbibe the moisture of the ground. In the nut within the outer shell there is a soft spongy substance, which, receiving the moisture, swells and bursts up the shell, and relieves the seed. The kernel of the nut is then like a common seed, it has begun to vegetate, and these are the parts which form the system of its economy. The principal part of the seed consists of albuminous matter for the supply of the nourishment to the embryo plant, so as to prolong its shoots, and to send down its roots into the earth. The little embryo plant lies complete in all its parts, betwixt the lobes of albuminous matter, in a state of torpor, or in which the operation of the living principle is suspended. From the embryo plant there extends into the albuminous matter of the seed-vessels, or tubes, inactive, but ready, on the supply of heat and moisture, to absorb the nutritious matter of the albumen, and minister to the increase of the embryo plant.

Now the root of the little plant sprouts from the seed, and has a tendency to strike into the ground, and the bud rises to the surface towards the light, and the influence of the atmosphere.

We see in this instance, that the operation of the system of tubes of the embryo plant in the albumen was merely suspended, that upon the seed being put into the ground, the heat and moisture promote the germination, and the nutritious matter of the albumen is carried to the embryo plant. In the first stage of this change, the matter absorbed by the vessels of the albumen supply that nourishment, which afterwards is conveyed from the root striking into the earth, and also what is supplied from the leaves absorbing from the atmosphere. And when the roots have struck into the earth, and the first leaves rise upon the surface, the lobes of the albumen are

exhausted and fade, or rise up in form of leaves, still cherishing the tender plants.

When we come accurately to examine the situation of the embryo in oviparous animals, we shall find the same provision for the nourishment and growth of the young animals, independent of external circumstances, the nourishment being prepared for it until it shall be enabled to gain strength to feed itself.

The manner in which an egg is formed is this:— The yolk, with its delicate membranes, is formed in the ovarium of the hen. The ovarium is placed on the backbone; innumerable yolks are seen gradually formed, and successively increasing in size. When they are matured, they are of the full size, and such as we see them in the perfect egg: they are surrounded with a delicate web of membranes, extremely vascular; the membrane of the yolk bursts when it is mature and impregnated, and then it falls into, or is grasped by the infundibulum, or what answers to the Fallopian tubes in woman and mammalia. While yet in the egg-bed, the embryo is seen to be included in its membranes, upon the surface, or in the membrane, of the yolk: it is called cicatricula; as the yolk and the cicatricula pass through the uterus, the yolk, in a most curious way, has the addition of the other part of the egg. The uterus of a bird is not like that of quadrupeds or viviparous animals, simply for the reception of the ovum; but it is long and convoluted like the intestines. And the yolk, as it drops into the upper part of it, collects as it passes along the uterus, the white of the egg, which is a secretion from the uterus. As it proceeds downwards, it receives the membranes of the white, and before it is excluded, it is coated with the shell to preserve it from injury when it shall be dropped from the hen. In the fully formed and incubated egg this is the situation of the parts. Under the shell is a membrane which invests the whole parts, but leaves a space containing air in the greater end betwixt it and the shell. Within this membrane the glairy white of the egg is contained, and within the white or albuminous matter is the yolk. Under the membrane of the yolk there is a small spot of a lighter yellow than the yolk. This, upon examination, is found

to be a vesicle, and within it we see a lesser circle formed by an inner vesicle: this is the cicatricula, and within this inner membrane the rudiments of the chick are contained. We may observe, that the yolk is specifically lighter than the white; and that it is fixed towards the two extremities of the egg, to the albumen, or white, by the chalaza. These are like twisted cords, which arise from the yolk, and expand in the white, so that they take a pretty firm hold on its tenacious substance. These chalaza are not fixed to the yolk in its axis, but to the side, so that the buoyancy of the yolk keeps it revolving as the egg is turned, so as always to present the cicatricula to the upper part of the egg, in whatever way it is placed; consequently it is always contiguous to the body of the hen, so as immediately to receive the influence of the maternal heat. By incubations the principle of life in the chick and its membrane, is roused, and the first perceptible change appears in little bloody streaks, which, running together, form a circle of vessels, and which are seen to terminate in the umbilicus of the chick.

This vascular circle, the most beautiful appearance of any in the economy of animals, ought to be particularly explained. In Mr. Hunter's book, treating of the blood, there is a plate which represents the embryo of the chick in the incubated egg, at three different stages of its formation, beginning with the earliest visible appearance of distinct organization. The preparations from which these figures are taken form part of a complete series contained in Mr. Hunter's collection of comparative anatomy. They are meant to illustrate two positions laid down in his work, viz. that the blood is formed before the vessels, and when coagulated, the vessels appear to rise; that when new vessels are produced in a part, they are not always elongations from the original ones, but vessels newly formed, which afterwards open a communication with the original.

This to me seems an idea founded on a very limited view of the state of the parts. We must recollect that this is not the formation of new parts or new vessels. The embryo is in that state of which I have endeavoured to convey an idea, by the term dormant: pos-

sessing that degree of life which is to be renewed by incubation, or artificial heat, but which will last a great length of time, and, like the germ in plants, be brought to vegetate only in particular circumstances. The tract of these vessels is laid in the original conformation of the embryo and surrounding membranes: they are now merely called into action, and we see only the effect of this action. We see red blood formed; we know that the redness of the blood is derived from the membranes, and matter which surround the embryo, and that it is conveyed to the chick or embryo. Before we allow ourselves to conjecture what is the first motion in the circle of actions which now take place, we must consider whether it be not more likely that the first action of these vessels is in absorption? that is, an absorption in the extremities of these vessels, or is there first an action of the heart of the chick? We are left to this question. Is it probable that a change shall take place in the fluids which shall stimulate the vessels? or shall the heat of incubation stimulate the vessels to act upon the contained fluids? or, as seems most probable, does the incubation, at the same time, produce a change in the fluids, and stimulate the vessels to action? To explain my opinion, I shall describe the probable series of actions.

In common seed, the small germ of the plant has its vessels passing out into the lobes of the albumen to absorb the food, whenever the peculiar circumstances necessary to its activity shall arrive. We have to observe, that where the nut was attached in its husk to the tree, it has left a porous part; by this cribriform kind of plate the moisture of the earth enters;—that dry scurfy substance which we observe on the inside of the shell swells with the moisture, which also penetrates the albumen or kernel—the moisture forming a combination with the albumen prepares it for absorption; the vessels are at the same time excited, absorb, and thus nutritious fluids are conveyed to the germ—the nut splits by the swelling of the parts, and the corculum or bud sprouts up. We find, then, that in this instance the grain, or nut, is brought into action by the fluids absorbed, forming new

combinations with the albumen or kernel, and the active exertion of the living powers, beginning by an operation in the fluids.

In the same manner, I conceive, that the incubation of the egg causes an action first in the fluids, not in the solids (for these are solids according to the strictest signification of the term; and strong membranes, as a little vinegar will show, when poured upon the albuminous substance of the egg). A change takes place in the fluids: there are new arrangements suiting them for absorption; and they are absorbed by that circle of vessels which is laid on the original formation of the membrane. The fluids act as a stimulus to those vessels, whose alternate action and relaxation commence, and never cease until the termination of life. I conceive this explanation, which I have offered, to be more consonant with the great principles of physiology, and an extensive analogy of similar actions in the economy, than that explanation of Mr. Hunter, which supposes the specks seen at the sides of the vessels to be spots of coagulated blood, destined afterwards to become blood-vessels. For I am apt to conceive the red blood to be formed only after several rounds of the circulation, and to depend upon a more perfect assimilation than that first excited; and that Mr. Hunter is all along in this mistake, that he is supposing these vessels to be newly formed, which are laid in the constitution of the membranes surrounding the embryo, and which are now only called into action, and only become apparent when they convey red blood.

In the system of the egg there are other circumstances worthy of notice: as the chick grows by the absorption of the white, or albumen, the new combinations reduce to a lesser bulk the whole mass, which is within the shell, and now we perceive the use of the air-cell, which, enlarging, fills up this space. When the chick has escaped from the shell, the yolk of the egg is not exhausted, but it is found to be received into the belly of the chicken, and to have a conduit leading into the duodenum, by which its nutritious matter is poured into the intestinal canal. It is for some time a source of supply to the

young animal until its strength is equal to the digestion of its appropriate food. And in this respect it is analogous to the suckling of viviparous animals.

Let us now observe what analogy exists betwixt the generation, or rather the birth and nourishment, of the embryo of the viviparous animal, and those of the oviparous. As to the precise effect which the approach of the male has upon the ovarium of the female, whether by this union of the sexes there is an actual addition to the ovum, or only an influence exerted on the parts already there by the presence of the male semen, it seems almost needless to hope for an absolute decision.

The resemblance of the offspring to both parents would influence us at once to conclude, that there must be a union of the parts from both sexes. But when we consider how much the peculiarities of individual animals depend upon certain peculiarities of action; how the constitutional predispositions must depend on the same peculiarity in the action of the vessels, since the doctrine of absorption teaches us, that of actual substance nothing is permanent, but all suffers an incessant revolution and change, we are forced to conclude, that nothing can remain but certain peculiarities of action, and we may then come to believe, that the male semen merely influences the state of the parts already formed, and does not bestow an actual substance.

In the speculations on the subject of generation, facts and observations have been so very rarely attended to, that those which have been offered seem to have had an influence beyond their real value. Thus the microscopical demonstration of animalculæ swimming in the semen of the male has given birth to an idea that they were homunculi, which being introduced into the proper nidus of the female, became the human fœtus. Though, where all is conjecture, and, perhaps, no better explanation is to be offered, it may seem improper so directly to contradict any theory, still I must say, that this is, in my mind, the height of absurdity. To suppose an animal secreted along with the seminal fluid from the testicle of the male, (which, in all probability, is the production of stagnation and putridity,) swimming and nourished in

the male semen, and yet to hold, that on being introduced into the ovaria it changes from an active animal into an impalpable gelatinous-like mass, and after a series of changes grows at last to the maturity of a human being, is altogether beyond comprehension.

The experiments made by the ingenious Dr. Haighton, throw considerable light upon these delusive speculations regarding the impregnation of the female. He found by experiments on rabbits, that upon cutting the Fallopian tubes, forty-eight hours after the coitus, the impregnation was equally obstructed as when he had cut them previous to admitting the male: it would appear that in these animals impregnation is by no means the instantaneous effect of the union of the male and female, but that it requires at least fifty hours; for when Dr. Haighton cut the Fallopian tubes at that period, it did not prevent impregnation. Dr. Haighton proves, that the generative process is not an instantaneous operation, as we should very naturally suppose, but an operation requiring time. That the semen does not reach the ovaria during, or immediately after, the coitus, is sufficiently evident; and it is still more so that the ovum is impregnated while in the ovarium, and not upon its descent into the womb, which is proved from the fœtus sometimes remaining in the ovarium, or tubes, and growing to maturity. Dr. Haighton supposes the semen only to affect the vagina and uterus, and that a consent of parts, or sympathy, is communicated along the tubes and ovary to the ovum; and that neither the semen nor the aura seminalis reaches the ovaria. When we look abroad for analogies, however, and find the semen of some animals, as fishes, merely thrown out upon the already evacuated spawn, we cannot readily acquiesce in this opinion of the mere sympathy of the female parts calling the young animal into life.

Leaving this subject, we have to observe, that previous to impregnation there is a ripeness and prominence of some of the ova, that by coition the Fallopian tubes do not instantly grasp, impregnate, and cause the bursting of the ovum from the ovarium; but there is an action commenced which gradually brings about this

change. Whilst the ovary is thus affected, the tubes are preparing for their action of embracing the ovum; there is an increased turgescence in their vessels, and an enlargement and swelling of the fimbriated extremity. When thus prepared, it approaches the ovarium, grasps and receives the ovum; and by a peristaltic motion, probably very slow and gradual, the ovum is conveyed into the cavity of the uterus.

OF THE OVUM, AND ITS CONNECTIONS WITH THE UTERUS IN THE EARLY MONTHS OF PREGNANCY.

The ovum, when it has descended into the uterus, and is perfect in its structure, is a soft oval mass, fringed with vessels, and composed of membranes containing the early fœtus. When opened, or dissected, it presents three cavities, or we observe the fœtus to be surrounded with three distinct membranes: — 1. The decidua, or tunica filamentosa, false chorion, or spongy chorion: — 2. the chorion: — 3. the amnios. Of these coats, the outer one is formed by the womb, the others constitute the ovum, as it has descended from the ovarium. We shall, in the first place, attend to the original membranes and general constitution of the ovum, and then to the deciduous covering which it receives in the womb.*

PLAN OF THE MEMBRANES.

A, the Fœtus; B, the Amnios; C, the Chorion; D, the Vesicula Alba.

AMNIOS. — The amnios is the vesicle which immediately involves the fœtus. It is a very thin and pellucid membrane in the early state of pregnancy, but it acquires considerable thickness and strength in the latter months.

* See Albin. Ann. Acad. lib i. cap. xviii. and xix. Hunter's tables of the Gravid Uterus. — Camper Icones.

The amnios contains a thin watery fluid, in which the fœtus is suspended. In the abortion of the early months we find the quantity of this fluid very great, in proportion to the whole ovum, and this forms a defence to the delicate and almost gelatinous substance of the fœtus, while it is a provision also for the regular presentation of the head of the child; for now the fœtus being suspended in this fluid, and hanging by the umbilicus, and the head and upper part of the body greatly preponderating, it takes that position, with the head presenting to the orifice of the womb, which is necessary to natural and safe labour, the fœtus being prevented from shifting in the latter months by the closer embracing of the child by the uterus.

Chorion. — The chorion is the second involving membrane of the fœtus: on the inside it is smooth, and betwixt it and the amnios a gelatinous fluid is interposed. In the early months it is much stronger than the amnios, but in the advanced stage it has come in contact with the amnios, no fluid being betwixt them. And in proportion as the amnios gains strength to be of essential service in dilating the orifice of the womb during labour, the chorion has relatively become very thin and weak. On the outside the chorion is shaggy and vascular, and constitutes those minute extremities of the vascular system of the ovum, which attach to the surface of the womb, or rather to the flocculent membrane which it throws out.

The umbilical cord.—When we can first discern the fœtus, it is merely like an opaque oval body of the size of a common fly, and closely attached to the amnios; but by degrees it recedes from it, and then we perceive that it is attached by the umbilical chord, which consists of the trunk of the vessels going out from the fœtus, and which, distributed upon the chorion, receives the supplies from the maternal system.

Now we perceive that the fœtal system which descends from the ovarium is not merely a fœtus or embryo, but that this embryo, besides a system of vessels within its own body, is surrounded completely with membranes, and that from the vascular system of the

embryo there go out vessels, which being minutely distributed to the outer vesicle, or membrane, and actuated by the same heart which circulates the blood through it, our little corporeal system prepares for imbibing the due nourishment from the uterus.

VESICULA ALBA. — The vesicula alba, or umbilicalis, is a little vesicle which lies betwixt the chorion and amnios: it contains a white fluid; it is connected with the navel or cord, by an artery or vein. Very little has been offered as explanatory of its use: it has been considered as similar to the alantoes of quadrupeds, and having a connection with the urachus; but it has no communication with the bladder, and soon disappears. Whereas, if it had been for receiving the secretion of urine, it would have been prepared for the more mature state of the fœtus.

I conceive it not to be improbable, that it is a provision of supply for the embryo, previous to its perfect attachment to the uterine system, and during its descent into the womb, perhaps similar to the albumen of oviparous animals, but which, after the perfect establishment of the connection betwixt the fœtal and maternal system, shrinks and disappears, as being no longer necessary.

OF THE ADDITIONAL MEMBRANES WHICH THE OVUM RECEIVES FROM THE UTERUS.

While the ovum is taking the changes consequent upon impregnation, the womb partaking of the general sympathy which prevails over the whole uterine system, suffers a change adapting it for the reception of the ovum. The first appearance of action in the womb is marked by a greater activity of the vessels, a swelling and softness of its substance. While on the inner surface there is an exudation, which, being converted into a spongy membrane, is peculiarly adapted for the reception and adhesion of the ragged and vascular surface of the ovum.

In the following plan we shall be able to observe the relations and inflections of the uterine membranes or decidua, as seen and described by Dr. Hunter, and of

their correctness my observations in dissection leave no doubt in my mind. AA, the uterus in outline; B, the amnios with the fœtus; C, the chorion. Now it is observed, upon a careful examination of an abortion of the early months, that besides the chorion and amnios, there is a spongy membrane, of two distinct laminæ which invests the chorion. The outermost of these is found to surround the whole ovum, even investing that part

which has become the placenta by the accumulation of vessels. This outer membrane, then, may be represented by the line DD. It is represented as adhering to the surface of the womb, as it must do in fact. We observe, again, that it is perforated where the Fallopian tube enters the womb; that at this part it is not formed; so that, according to Dr. Hunter, and the preparations which I possess, these tubes open into its inside.

Upon dissecting up the outer lamina of the decidua, we find that where the placenta commences, it is reflected over the surface of the ovum and the shaggy chorion of the ovum, so as to be represented by the letters EE. We shall now understand the distinction betwixt the Decidua Vera DD, and the *Decidua Reflexa* EE.

It would appear that this membrane is either completely formed, or at least the fluid which is to form it is thrown out previously to the descent of the ovum: indeed, so intimate is the sympathy betwixt the whole uterine system, that this membrane is formed in those cases where the ovum does not descend, but constitutes the extra-uterine conception.

Dr. Hunter supposed, that the ovum passed into the cavity of the uterus, whilst the coagulable lymph was pouring out by the arteries of the uterus, and that it was thus immersed in and surrounded by the decidua; for he could not conceive that it could gain admission betwixt the lamina of the membrane already formed.

The only other supposition is, that the ovum A, upon its descent, gets entangled behind the deciduous membrane B, by which means the ovum is not left loose in the cavity of the womb, but it is soon attached and surrounded with a membrane, or vascular web, from which it can immediately draw supplies, and by this provision also its adhesion to the superior part of the uterus is ensured. But as the same action of the uterus continues, and, as we must naturally suppose, is rather excited by the presence of the ovum in its cavity, the surface of the uterus at A continues to throw out a coagulable matter which surrounds that part of the ovum, so that this will immediately become its situation.

A, The *decidua vera*, formed before the descent of the ovum; B, the *decidua reflexa*, formed by the ovum getting behind it and pushing it down; C, the efflorescence formed by the coagulable lymph which

was poured out after the descent of the ovum, which, being interposed betwixt the ovum and uterus, will form the uterine portion of the placenta.

OF THE PLACENTA, AND OF THE NUTRITION OF THE FŒTUS.

When the ovum first descends into the uterus, the fleecy surface of the chorion establishes a universal adhesion; but no sooner is the attachment of the ovum confirmed, than the vessels of the fœtus, which are universally distributed over its surface, begin to accumulate to that point from which the more abundant supply is obtained. Thus, from the universal adhesion, the vessels of the fœtus are massed and accumulated together, so as to form a thick cake or placenta. This takes place upon the same principle that the roots of a plant stretched towards the soil best suited to it, or the branches and leaves of a plant grow and spread towards the light. The placenta is destined to adhere to the fundus of the womb, and there we observe the accumulation of the large vessels of the womb, it being equidistant from the several sources of blood; and to this point is the tendency of the vessels of the chorion so great, that we sometimes see the vessels of the cord running three or four inches upon the membranes before they reach the placenta, evidently showing that the point to which the umbilical cord had been originally attached was not opposite to the more vascular part of the womb; but that the vessels had to stretch and elongate some way from the insertion before they accumulate in form of the placenta, towards that part of the uterus where there was the greatest vascularity.

But the formation of the placenta on the fundus of the womb is not constant, although there are many provisions for insuring attachment there. But when it does form low in the womb, or on the orifice itself, we then perceive the reason of nature's solicitous care in preventing it; for it occasions the most dangerous

floodings from the placenta presenting on the approach of labour, and its connections being necessarily torn up previous to the delivery of the child.

The placenta of the advanced stage of gestation is a mass formed partly by the accumulations of the vessels of the fœtus (the trunk of which is the umbilical cord), and partly of a vascular and cellular portion formed by the uterus. On the surface attached to the womb, the placenta exhibits deep and irregular fissures which divide it into lobes. The inner surface is smooth from the investing membranes, but raised into irregularities by the numerous and tortuous ramifications of the umbilical vessels. When rudely torn or cut into, it appears to be a spongy substance, formed in a great part of an irregular tissue of vessels and cellular substance.

In the human subject we find, that the maternal part of the placenta is thrown off with the other secundines, and does not separate from the fœtal part of it. While, in other viviparons animals, the monkey excepted, the filamentous extremities of the fœtal vessels separate from the mass formed by the maternal vessels of the uterus.

The placentary vessels of the fœtus never touch the surface of the womb, but communicate with the maternal system through the vessels of the womb, which pierce the deciduous membrane. Still the question of the precise manner in which the vessels of the fœtus communicate with those of the mother remains undetermined. I conceive that in the early stage the deciduous membrane being thrown out by the action of the uterine vessels, those of the chorion stretch into it, and absorb the nourishment. The decidua is a vascular membrane, but it has, at the same time, a peculiar spongy texture. This spongy or reticulated structure of lamina of the decidua ceases where the placenta is affixed. When we carefully dissect up the decidua to the margin of the placenta, it is found to be more rigid, white, firm, and thick.* When we examine the outside of an entire ovum, we observe, that at the place

* I speak after dissecting the ovum of the third month.

covering the placenta it is corrugated and full of irregular eminences like the convolutions of the brain, and amongst those irregularities many small convoluted arteries may be discerned, with spots of extravasation and the flat mouths of veins. Upon dissecting up this maternal part of the placenta, we find it to form the firmest part of it; and by the difference of colour, as well as by the possibility of tearing it up, or dissecting from the mass of vessels of the chorion, we recognise it as the decidua. This union, however, betwixt the maternal and fœtal parts of the placenta is intimate; and it is impossible to determine by dissection with the knife, whether there be inosculations betwixt the maternal and fœtal vessels, or whether the nourishment of the fœtus is by absorption; nor can we distinguish in the first months the cellular intertexture which may be observed in the placenta of the full time, as described by Mr. Hunter.

In explanation of this part of our subject, I have purposely dissected, and made drawings of the ovum in several stages.

OF THE LIQUOR AMNII, AS CONDUCING TO THE NOURISHMENT OF THE FŒTUS.

Some physiologists, observing the analogy which exists between the function of the placenta and the lungs of breathing animals, have conceived that the liquor amnii is the source of nourishment, and that it is taken into the stomach. I believe they have conceived some analogy to exist betwixt the albumen of the egg and the liquor amnii, which in their minds has strengthened this opinion. But there is here no analogy: we have seen, that the embryo of oviparous animals being formed with the yolk in the egg-bed or ovarium, descends into the uterus, and there receives the addition of the albumen or white. On the other hand we find that the ovum of viviparous animals is formed in the ovarium; and that the liquor amnii being within the membranes of the ovum, must be the production of the fœtal sys-

tem. Further, when the ovum has descended into the womb, and grown to some maturity, we see that there is no connection by vessels betwixt the fœtus and mother, but through the placenta; that the liquor amnii is within the involving membranes of the fœtus, and that, consequently, it must be thrown out by the vessels of the fœtal system. Thus, to suppose the fœtus to be fed by the liquor amnii, would be to suppose it to draw resources from its own system, and that the vessels poured out a fluid, which is afterwards to be taken into the stomach.* But without adducing arguments, it is sufficient to say, that fœtuses have been brought forth, monstrous in their conformation, and without mouths, yet well grown.

Of the placenta as the source of nourishment to the fœtus. —When we consider the mere speck of the embryo in the first weeks, we see that it can have no other source of nourishment than through the extreme vessels of the chorion, connected with the short umbilical cord; and we may be convinced, also, that in its progress to maturity, when the general connections of the chorion cease, and the placenta is formed, the sole supply is through its vessels. Regarding the manner of the communication betwixt the vessels of the mother and child, there are many opinions. The simplest explanation, but the furthest from the truth, is, that the arteries of the womb are continued into the veins of the fœtal portion of the placenta. That, on the other hand, the arteries of the fœtal system are continued into or inosculate with the veins of the womb; and that thus the blood of the mother's system is carried by direct inosculation.

A little investigation will convince us, that this is a very unlikely conjecture. We see the embryo surrounded with its vessels, and forming a complete system within itself, descend into the womb. We see that the attachment betwixt the surface of the ovum and the

* A greater absurdity than that of which a foreign author is guilty cannot be imagined; because the liquor amnii, or some fluid, is found in the trachea, he supposes that a fœtus respires, and receives oxygenation from the liquor amnii.

womb depends on a reciprocal action between them; and when the fœtus is feeble, or diseased, or when it dies, the uterus immediately separates from it, as from a dead part, and there is an abortion. Again, it is not natural to suppose, that the circulating fluids of the adult are calculated for the circulation in the embryo, or that the blood of the adult is fit for the circulation of the fœtus. When we inject the vessels of the fœtus, we find the veins and arteries of the umbilical cord to inosculate freely with each other, and the fluid passes from the arteries to the veins with little extravasation or escape of fluid, and such only as may be supposed to pass from torn vessels. Again, the bleeding of the child does not draw from the maternal system; for example, when the accoucheur has to perform the operation of embryoulcio, and when the arteries of the brain pour out their blood, the woman does not suffer, nor is there any danger of hæmorrhage from the cord after the delivery of the child. Again, what does the analogy of other animals show us? We may observe, in the first place, that, probably on account of the peculiar form of the womb of woman, and in these circumstances to guard her from danger of hæmorrhage during delivery, it is necessary that the placenta should be accumulated towards the fundus of the womb. Now, to allow less danger of the separation of the secundines from the womb, and consequent abortion, there follows a necessity for the human placenta being attached in a particular manner; and in place of the maternal part of the placenta remaining with the womb, as in other animals, the whole mass separates on the delivery of the child. The necessity for this firmer attachment of the human placenta causes the connection betwixt the fœtal and the maternal portions to be very intimate, and the manner of the vascular connection by no means easily demonstrated.

In other animals, however, for example, in those which have the small and numerous placenta, or cotyledons, the fœtal and maternal portions of the placenta separate easily; the maternal part being a prominent vascular bed, which is a part of the womb, and is not

deciduous. Here we find, that the glandular-like portion which belongs to the womb may be minutely injected, and no particle of colour pass into the fœtal part; and again, injection shows the fœtal portion to be merely composed of the fleecy extremities of vessels, which, however minutely injected, do not show any inosculations with the maternal vessels; in short, here the connection betwixt the extremities of the two systems is so very loose, and the filaments so minute, that we can imagine no other kind of connection, than that the extremities of the umbilical vessels take up by absorption the nutritious matter necessary for the system of the child, and that this is secreted by the vessels of the womb.

Investigation in every department of natural history shows a similarity and a simplicity in the operations of nature. Comparative anatomy may be brought with much advantage in illustration of the very obscure laws which guide the functions of the parts of generation. When we turn our attention to the egg, we find, in the first place, that the vascular system is complete within itself, and requires no permanent connection with the maternal system to invigorate its action. We find that the artery which passes out of the umbilical cord of the chick, and which is distributed to the membranes of the white, pulsates strongly, and carries venous-coloured blood. We find the returning vein carrying arterial-coloured blood. We find, then, that these vessels must have a double function: they imbibe the nourishment from the white, and convey it to the increase of the chick; and they at the same time perform an action similar to that of the pulmonary vessels of the adult, seeing that they carry out dark-coloured blood, and convey it back to the chick, of a bright vermilion colour. Now, I do not conceive that this change upon the blood is performed by the communication of the atmosphere through the shell, for I see no distinction in the colour of the vessels, which are contiguous to the membrane of the shell, and those which are removed from it by the expanding of the air-cell. Further, we find that there is an intermediate kind of generation in fishes which are

oviparous, but retain the egg within their womb, until the fœtus is matured: here no communication with the air or water can be allowed.

Since we see that the chick in ovo is capable of ministering in every essential particular to its own increase, wherefore should we suppose that the fœtus of viviparous animals has any other more particular connection with the womb of the mother?—The difference is, in my mind, this simply; the ovum of the oviparous animals descending through the convoluted and intestinal-like uterus of the hen, accumulates a quantity of matter around it, which serves every purpose of nutrition when the embryo shall be finally separated from the maternal system; but in the viviparous animals the ovum descending into the womb, remains there, and has a continual supply of nutritious fluid, secreted from the vessels of the womb, as it is required by the fœtal system. As in the egg, the membranes surrounding the white have the same effect upon the blood, which is afterwards produced by the lungs; so has the placenta of viviparous animals the double function of supplying nourishment, and the purifying of their blood. The umbilical vein carries back pure arterial blood, and the common opinion is, that the blood of the fœtus coming in contact with the blood of the maternal system, receives the principle from it, which bestows this quality of colour, with other necessary qualities, of which this of colour is but the sign to our observation; or we may say that the carbon of the fœtal blood is imbibed by the maternal blood; and in this way the blood of the fœtus is purified. It is not necessary to this change, on the fœtal blood, that it should come in immediate contact with the maternal blood, for it is possible, that the matter thrown out by the maternal vessels, whilst it is nutritious, has also in it, in a condensed and not a gaseous form, that which is essential to the change of the blood of the fœtus from the modena colour to bright vermilion.

OF THE EXTRA-UTERINE CONCEPTION.

We find some curious facts relating to the action and sympathy amongst the parts of generation, proved by the cases of extra-uterine conception, where nature, baulked and interrupted in her usual course of operation, shows unusual resources. It would appear, that the ovum, after impregnation, has, in some cases, remained attached to its original seat in the ovarium, perhaps owing to some want of due sympathy, and synchronous action of the Fallopian tubes, which should grasp and receive the ovum. In other instances the ovum has been received into the Fallopian tubes; but either from a want of sufficient dilatation and action in them, they have not been able to propel it forward, or the ovum, taking upon it that action which is destined to form its connections with the uterus, adheres, and is enlarged in the tube, so that it cannot be conveyed down into the womb.

I am not so fully satisfied of that kind of extra-uterine conception, where, after impregnation, the ovum has dropped from the ovarium, and lies in the cavity of the abdomen amongst the viscera. Here it is supposed the vessels of the fleecy chorion spread, and attach themselves to the surface of the viscera. I believe that the cause of the extra-uterine conception is previous adhesion, which prevents the action of the Fallopian tube. In two cases of extra-uterine conception, I have known such adhesion to be a consequence of disease in the lower part of the colon.

These instances of deviation from the natural action of the parts after conception prove to us, I think, that from the moment of impregnation there is a principle of life and activity in the system of vessels of the ovum, and that at a stated period this action becomes such, that the efflorescent vessels of the surface of the ovum attach themselves to whatever vascular surface they are in contact with. Further, it seems to show, that in the womb, and in the deciduous membrane which it prepares for the reception of the ovum, there is nothing

very particularly necessary, and that any vascular surface will take upon it the same changes, and being excited probably to some peculiarity of action, will, in every thing essential, supply the growth and nourishment of the ovum and fœtus.

It shows us how far the action previous and consequent to impregnation is a universal and sympathetic excitement of the uterine system; that the decidua is formed in the cavity of the womb, although the ovum does not descend. This points out to us how careful nature is, that there shall be a reciprocal action in the ovum and womb, so as to insure the adhesion of the ovum, and the ready supply of a proper nidus for it, when it shall have descended into the cavity of the womb. It informs us, that the uterus is a spongy and vascular bed, having peculiar sympathies which actuate its vessels, and a form of vessels adapted to quick acceleration of action, so as to grow, and supply the secundines with nourishment.

It is not, however, in the mere adhesion and supply afforded to the fœtus, that the peculiar adaptation of the womb for the reception of the fœtus is shown, but in the provision for the delivery of the child at a regular and stated period. For it is a curious fact, that in the case of extra-uterine fœtus on the expiration of the nine months, the uterus takes upon it that action, and that excitement of its muscularity which is destined to expel the fœtus. We find, that at the usual time of utero-gestation there are pains excited, and flooding, with the discharge of the decidua from the womb, although it contains no fœtus.

Nay, further, it would appear from the result of several cases, that at the expiration of the natural term of utero-gestation, the fœtus indicates that it is governed by prescribed laws, which render a change necessary, and show that its system is no longer fit to be supplied through the placentary vessels; and as in the situation of extra-uterine fœtus this change cannot take place, it dies, and becomes with its secundines as a load of foreign or dead matter in the belly. This event is generally followed by the death of the mother, though sometimes an abscess has opened and discharged the

fœtus, or after much suffering, the bones have been discharged by stool, at long intervals.

OF THE WOMB AT THE FULL PERIOD OF GESTATION, AND OF DELIVERY.

To complete this view of the female parts of generation, it remains only to speak of the state of the parts at the full term of nine months, and to observe the process of a natural delivery.

The rapid increase of size of the pregnant womb, in the short space of nine months, is, perhaps, the most surprising phenomenon of the whole animal economy: it shows the power of a peculiar excitement in calling into action a partial and local system of vessels. This state of pregnancy is the furthest from a state of distention, insomuch, that it is observed the womb feels peculiarly soft on impregnation, and as if but imperfectly filled by the ovum. This soft state is a sign of vascular action. We may often observe in the discussion of a tumour, that before any change takes place, it swells and becomes soft, and this even where the tumour is about to be absorbed.

The fundus of the uterus is the part first enlarged, and afterwards the inferior parts; at length the cervix is obliterated, and the uterus, which was originally pyriform, becomes nearly oval; the distention, however, as we have remarked, is greatest on the back part of the womb. In the first months the uterus sinks lower in the pelvis, they say, from its weight; but the specific weight of the uterus is not increased, and on that account it should not sink deeper; it is, perhaps, rather from its enlargement, and the difficulty with which the fundus makes its way among the viscera in the brim of the pelvis. Having descended considerably, the os tincæ projects further into the vagina; but the fundus continuing to enlarge, at last emerges from the circle of the bones, and then from the conical form of the uterus, it sometimes rises suddenly out of the pelvis: now the vagina will be found elongated, and the os tincæ removed from the point of the finger.

Now the ligaments of the womb direct it forward, and it rises close upon the abdominal parietes, and before the bowels: in the first pregnancy, it rises almost directly up; in subsequent pregnancies, from the greater relaxation of the integuments and the abdominal muscles, it is allowed to fall more forward; about the fourth month of pregnancy, the womb may be felt in the abdomen, and rising out of the pelvis; in the fifth month, the fundus is about half way betwixt the pubes and navel; in the seventh, it is about half way betwixt the navel and scrobiculus cordis; in the eighth month, it is at its highest, and towards the end of the ninth month, it rather subsides. Finally, immediately before labour, it descends remarkably, and shifts into the middle of the pelvis, so as fairly to present the orifice of the womb.

The muscularity of the uterus is increasing from the first moment of pregnancy. As the uterus increases in thickness and is distended, the muscular fibres become more distinct, and their power of contraction greater; but what is very particular, is the great muscular efforts made by the womb during labour by these fibres, which have not till that time felt the stimulus to action, or been allowed to contract.

When the period for the approach of labour is arrived, the nature of that viscid secretion which seals up the orifice of the womb is altered; it loses its viscidity, and all the parts are relaxed and prepared for the transmission of the head; even those rigidities, strictures, or callosities of whatever kind, which would seem to promise an absolute obstruction to the passage of the child, yield and relax previous to labour. The action of the womb is at first feeble, as might be expected, and accoucheurs have marked these stages of a natural labour:—

1st. The uterus has suffered no diminution of its size: the membranes are entire, and, of course, the contractions of the uterus are feeble, because, before it is allowed to make some contraction, its efforts are not strong. This is a provision for the first stage of labour being slow; by and by the orifice dilating, the membranes with the waters are felt protruding. The membranes and water are as a soft conical cushion, gently dilating

the passage; and in this stage there should be no officious interference. While the membranes are entire, both the mother and child are in perfect safety.

2d. The orifice continuing to dilate, and the efforts of the womb increasing, the membranes burst, and the head of the child presses on the orifice; then the womb is allowed to contract: this contraction is a stimulus to greater efforts, and in a few pains, the head descends into the cavity of the pelvis. The orifice is completely retracted, and there is no longer a mark of division betwixt the womb and the vagina; they are as one canal. If, however, the membranes are burst too early, the labour is not accelerated, but retarded. The orifice is not dilated by the soft and elastic membranes; the head of the child presses broad on the orifice, which becomes rigid, and perhaps inflamed; its dilatation is slow, and the labour tedious. Though from the form of the bones, and particularly by the retiring of the sacrum, there is a provision and guard for the soft parts of the mother against compression by the head; yet nature intends this stage to be short, for it is the period of danger. There is now obstruction of urine and fæces, and the vessels of the parts suffer compression.

3d. Now the head of the child presenting at the orifice of the vagina, forms a third stage; it is the stage of most exquisite suffering: the head is pushed forward during every pain, and recedes again in the absence of pain. An interval of rest precedes this stage. At last the pains return, and the hard head of the child coming to press on the orifice, and the womb coming in close contact with the body of the child, the pains are redoubled in strength. The face of the woman, perhaps before pale and flat, becomes red and turgid, the eyes gleam, and are inflamed; the pulse becomes quick and hard; and from the exquisite expectation of relief, she looks wildly round on her attendants, losing all reason and recollection; she is frantic, with the most agonising pain to which the human frame is subject. Now the occiput of the child begins to project with its wrinkled scalp through the external parts; but nature intends

that this also should dilate slowly; the ligaments and os coccygis resist several throes, and direct the head forward under the pubes. At last, after several pains, it rises with a half turn, and is delivered.

4th. The fourth stage, is the delivery of the body and shoulders; and,

5th. The fifth stage is the delivery of the placenta. The placenta is expelled by a continuation of the same action of the womb, and is part of the natural process. First a flow of the liquor amnii and blood follows the child, and the woman lies for a time exhausted; the extreme pain and excitement having ceased. The womb generally recovers its powers in about twenty minutes, and then there is grinding pain in the belly, and the placenta is detached and expelled, or is pushed down into the vagina.

Thus we have sketched, in the most superficial manner, the progress of a natural labour, with a view merely to explain the general notion of the entire function of the womb, not with that minuteness which the accoucheur would look for in treating the subject. Let us for an instant attend to the state of the umbilical cord, and the final contraction of the womb.

I have already observed, that while the membranes are unbroken the child is safe, that is to say, there is no danger of the compression of the umbilical cord; but when the membranes have burst, and the waters are evacuated, the cord must suffer a degree of compression betwixt the uterus and the child, and there is danger that the cord may fall down before the head, until the head has descended into the brim: as the uterus contracts, and as it were follows the child, the circulation through the placenta must become somewhat difficult, and the usual function corresponding with that of the adult lungs impaired. This must be much more the case when the child is delivered, and the placenta remains in the contracted womb. No doubt nature intends by this, that the function of the placenta shall be gradually diminished, and not suddenly cut off, that the child may feel occasion for the play of the muscles of

respiration, and that the function of the lungs may, by degrees, take place of the function of the placenta. When the child is first delivered, the cord pulsates strongly; when the child cries, it becomes feeble. At first the child has strong and irregular catches of the respiratory muscles, but by and by it breathes more regularly, and cries lustily. At first, the breathing only renders the pulsation of the cord feeble, but presently the pulsation becomes so weak that it is felt only near the umbilicus, and it ceases when the regular and uninterrupted breathing is established, and the crying ceases.

The delivery of the child and placenta is followed by a considerable efflux of blood. But after this there continues a discharge from the uterus which is called the lochia. It is like the exudation of blood from an extensive wound, in as much as by the contraction of the vessels from which it flows, it becomes serous in a few days, and ceases gradually like a hæmorrhage.

This open discharge from the womb after delivery, is no doubt a provision against the consequence which would naturally result from the sudden and perfect obstruction and the activity of the uterine vessels consequent on delivery. By this discharge the activity of the vessels is gradually relieved, and as it is a discharge taking place of the active state of the womb, so the secretion of the milk in the breasts, and the giving of suck, causes the discharge to cease much sooner than it would do if the mother were not the nurse.

OF THE MUSCULARITY OF THE UTERUS.

I have dissected the gravid uterus in all conditions: in women who, in consequence of fever, died undelivered; in women who died from flooding, and in women who died in consequence of distortion of the bones: I have had two opportunities of examining the uterus ruptured by its spontaneous action; and one, in which the uterus had been ruptured by violence; and,

finally, I have examined the state of the uterus after death in consequence of the Cæsarian section.*

In this way I have been led to attend to this subject as an anatomist, rather than as an accoucheur; an explanation which, I fear, will seem very necessary in apology for these observations.

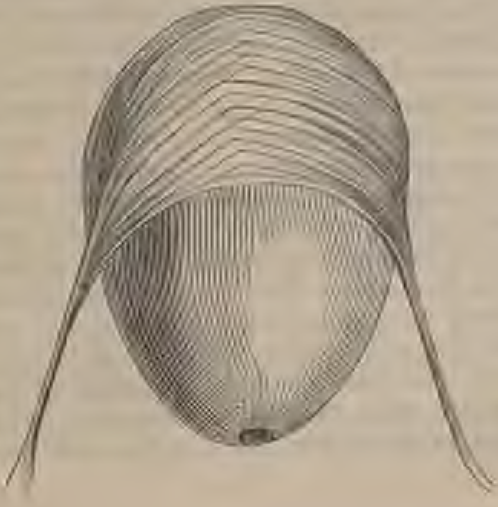
OF THE MUSCULAR STRUCTURE OF THE UTERUS.

The muscularity of the uterus is proved by direct ocular demonstration of the fibres in dissection; by the thickness of the fibres corresponding with their degree of contraction; by the visible action in the human uterus during life; by the resemblance of the laws of its contraction (as felt and as perceived in its consequences) to those which govern the contraction of the other hollow viscera; and, lastly, by the vermicular and intestinal motions of the uterus as seen in experiments upon brutes.

The prevailing notion that the muscular fibres of the uterus are very confused, and scarcely perceptible, has prevented authors from founding the rules of practice on the sure ground of anatomy. And if it be possible to place this matter in a clear light, it may banish, perhaps, a certain vagueness which is much to be regretted in so important a department of practice. The most curious, and obviously useful part of the muscular substance of the uterus, has been overlooked; I mean the outermost layer of fibres which covers the upper segment of the gravid uterus. The fibres arise from the round ligaments; and, regularly diverging, spread over the fundus, until they unite and form the outermost stratum of the muscular substance of the uterus. The round ligaments of the womb have been considered as useful in directing the ascent of the uterus during gestation; so as

* I wish that my present subject permitted me also to state what I have found on dissecting the parts after the use of the crotchet, and in particular where the forceps had been used, as I must presume, in a case improper for them. The injury which the seeming harmless instrument, the forceps, is capable of doing might then be proved, and a wholesome admonition given to the young surgeons.

to throw it before the floating viscera of the abdomen: but, in truth, the uterus could not ascend differently; and on looking to the connection of this cord with the fibres of the uterus, we may be led to consider it as performing rather the office of a tendon than that of a ligament. It is familiarly known, that the subsiding of the belly in pregnancy occasioned by part of the womb sinking within the brim of the pelvis, is the least equivocal sign of the approach of labour, and of the pelvis being of due dimensions; and in some measure this is also an assurance of a right presentation of the child. This layer of muscular substance operating on the round ligaments is well calculated to assist in expelling the fœtus; but also in a particular manner it is provided for bringing down the womb in the first stage of labour, and it is well calculated to give the uterus and the head of the child the right position with regard to the axis of the pelvis. From the connection of the lower extremities of the ligaments with the tendinous insertions of the abdominal muscles, we can conceive that this muscle and these ligaments may shift the position of the womb, and carry it off from the support of the ilium; but otherwise we should be at a loss to conceive how the uterus by its own action could adjust the position of the orifice for the delivery of the child.



On the outer surface and lateral part of the womb, the muscular fibres run with an appearance of irregularity among the larger blood-vessels; but they are well calculated to constringe the vessels whenever they shall be excited to contraction. The substance of the gravid uterus is powerfully and distinctly muscular, but the course of the fibres is here less easily described than might be imagined. This is owing to the intricate interweaving of the fibres with each other; an intertexture, however, which gradually increases the extent of their power, in diminishing the cavity of the uterus. After making sections of the substance of the womb in different directions, I have no hesitation in saying, that towards the fundus the circular fibres prevail; that towards the orifice the longitudinal fibres are most apparent; and that, on the whole, the most general course of the fibres is from the fundus towards the orifice. This prevalence of longitudinal fibres is undoubtedly a provision for diminishing the length of the uterus; or for drawing the fundus towards the orifice. At the same time these longitudinal fibres must dilate the orifice, and draw the lower part of the womb over the head of the child.

In making sections of the uterus, while it retained its natural muscular contraction, I have been much struck in observing how entirely the blood-vessels were closed and invisible; and how open and distinct the mouths of the cut blood-vessels became, when the same portions of the substance of the uterus were distended and relaxed. This fact of the natural contraction of the substance of the uterus closing the smallest pore of the vessels, so that no vessels are to be seen, where we nevertheless know that they are large and numerous, demonstrates that a very principal effect of the muscular action of the womb is the constringing of the numerous vessels which supply the placenta, and which must be ruptured when the placenta is separated from the womb.

I have observed further, that although in producing contraction and thickening of a portion of the uterus, by boiling it, or by other artificial means, the fibres are made very evident, and the blood-vessels greatly con-

stringed; yet they are not so effectually closed as in the natural contraction of the muscular fibres of the uterus. Thus we are led to contemplate the uterus as more peculiarly destined for the safe delivery of the secundines, than for the reception and growth of the ovum. Although its system of vessels be admirably adapted for an increase of action, and for rapid growth, yet it is not so peculiar in this respect as in its muscular structure; for we find that where the fœtus lodges in the ovarium it grows within the term of uterogestation, to the full size: but if the ovum separates from the ovarium, or from the Fallopian tube, in the example of extra-uterine fœtus, the woman dies of hæmorrhage, the blood flowing without being restrained by any system of muscular fibres capable of constringing the blood-vessels which are necessarily ruptured.*

The celebrated Ruysch discovered a circular muscle on the inner surface of the fundus of the uterus.† The use of this muscle, as he conceived it, is to draw the surface of the uterus by a gliding motion from the corresponding surface of the placenta, and thus to separate it and cast it off. By some the existence of this muscle of Ruysch is not admitted; and it has been supposed that he was deceived by the appearance of tortuous vessels.‡ I have nearly an absolute reliance on the observations of Ruysch; and as I have made a section of the uterus, most exactly corresponding with the engraving in Ruysch's work, I must conclude that he was not deceived in what he saw.

In the papers of Dr. Hunter, published by Dr. Baillie,

* See a case by Dr. Clarke. Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge. Mr. Taunton showed me the parts where a rupture of the Fallopian tube in a case similar to this of Dr. Clarke had occasioned a fatal hæmorrhage into the cavity of the abdomen. A lady under my care for disease of the rectum died suddenly, with symptoms of internal hæmorrhage. She left a request that I should examine into the cause of her death. I found the membranes of an extra-uterine fœtus, at the third month, had burst and shed the blood into the abdominal cavity.

† Ruysch, Dec. 2. p. 34.

‡ By Boerhaave and Albinus. See in the Opuscula of Sandifort the words of Professor Germ. Azzoguidus, who has also the idea.

there is the first accurate observation of the concentric fibres which surround the openings of the Fallopian tubes; the description corresponding with the circular strata of fibres which Weitbrecht has seen encircling the mouths of these tubes.

Upon inverting the uterus, and brushing off the decidua, the muscular structure is very distinctly seen. The inner surface of the fundus consists of two sets of fibres, running in concentric circles round the orifices of the Fallopian tubes. These circles, at their circumference, unite and mingle, making an intricate tissue. Ruysch, I am inclined to believe, saw the circular fibres of one side only; and not adverting to the circumstance of the Fallopian tube opening in the centre of these fibres, which would have proved their lateral position, he described the muscle as seated in the centre of the fundus uteri. This structure of the inner surface of the fundus of the uterus is still adapted to the explanation of Ruysch, which was, that they produced contraction and corrugation of the surface of the uterus, which the placenta not partaking of, the cohesion of the surface was necessarily broken.

Further, I have observed a set of fibres on the inner surface of the uterus which are not described. They commence at the centre of the last described muscle, and having a course at first in some degree vortiginous, they descend in a broad irregular band towards the orifice of the uterus. These fibres, co-operating with the external muscle of the uterus, and with the general mass of fibres in the substance of it, must tend to draw down the fundus in the expulsion of the fœtus, and to draw the orifice and lower segment of the uterus over the child's head.

I have not succeeded in discovering circular fibres in the os tincæ, corresponding in place and office with the sphincter of other hollow viscera, and I am therefore inclined to believe that, in the relaxation and opening of the orifice of the uterus, the change does not result from a relaxation of muscular fibres surrounding the orifice. Indeed, it is not reasonable to conceive that the contents of the uterus are to be retained during the nine

months of gestation by the action of a sphincter muscle. The loosening of the orifice, and that softening and relaxation which precedes labour, is quite unlike the yielding of a muscular ring.

NATURAL ACTION OF THE UTERUS.

While the uterus retains its whole contents, the action of its fibres is slow and feeble. Its first movement is to shift its position to direct the orifice aright, and to sink down until the lower segment of the womb rests upon the brim of the pelvis; this it does by the operation of the muscular fibres on the round ligaments, and during this shifting of its position are experienced the true dolores præsagientes. When the waters are discharged, the contractions are more powerful, the child's head presses on the orifice, and the fundus and body of the uterus are more powerfully excited. Now the upper and middle part of the uterus contract; but it is evident that the lower part of the uterus must, during this contraction of the upper part, relax and stretch to permit the child's head to pass. While the child is contained in the uterus, the muscular fibres cannot greatly contract nor impede the blood in the circulating vessels of its substance. But when the child is expelled, then the contraction of the fibres is considerable, and then they take that arrangement which is inconsistent with a free circulation of the blood; the vessels are constringed. By the time that the placenta is expelled by the contraction of the uterus, the vessels of the uterus are closed, and no active hæmorrhage follows.

ACTION OF THE UTERUS PRODUCING RUPTURE.

I have examined two cases of uterus ruptured by its spontaneous action, and one in which the violent attempts at delivering the child ruptured it. In the two first examples the circumstances of the labour, and the appearances on dissection, had a close resemblance. The labour was going on apparently well, when, after a violent pain, the woman vomited a dark matter: on

examination, the child's head had receded; on putting the hand on the belly of the woman, the form of the child could be distinctly felt. Such was the description I heard, when I came to open the body in the first case. I found the fœtus, cord, and placenta lying among the viscera, and the uterus contracted and drawn into the pelvis. The head of the child I found unusually enlarged by hydrocephalus. In the second case, the uterus only was brought to me. In both, the uteri were largely rent transversely, just within the orifice of the fore part; and the margins of the rents were thin and ragged. In the first, the orifice of the uterus was dilated and obliterated: in the second, the lips of the orifice were still distinguishable, being imperfectly dilated and rigid.

In the third case of rupture of the uterus, which I dissected, the circumstances were very different: I went to see a woman, who, being remarkably distorted, I thought could not survive her labour. I found a gentleman engaged in assisting her; he had proceeded, I believe with perfect propriety, to deliver the woman with the crotchet; he had evacuated the cranium, and brought away the frontal and parietal bones: he had got the hook into the foramen magnum, and was endeavouring to bring down the base of the cranium laterally, to accommodate it to the flattened pelvis. In this, however, he could not succeed. On returning next day I found the patient dead: the body was afterwards conveyed to me. On opening the abdomen I found the uterus still containing the body of the child, and the placenta; but an arm and shoulder projected through a rent on the left side and lowest part of the uterus: it was covered with slime and mucus, and the lips or margin of the rent were quite black and sloughy. It required my whole strength, standing on the table, to draw back the remains of the child's head, which were wedged in the distorted pelvis.

In the first instance I think the cause of rupture was, that the dilatation of the orifice of the womb was insufficient to admit the preternaturally large head to pass. In the second, the rupture was owing to the rigidity and

insufficient dilatation of the orifice of the uterus, while the muscular action of its body was powerful. We know very well, that a muscle during action acquires an additional power of cohesion, and consequently additional strength, but that when relaxed it is comparatively weak. This explains why the rupture takes place at the lower part of the uterus; for there we find, that during the most powerful contractions of the womb, there must be relaxation and dilatation to admit the child's head to pass, and that relaxation is weakness.* In the third case, the remote cause of the rupture was the obstruction to the labour, from the wedging of the child's head; the child being forced by the action of the womb into the pelvis, and by the pulling of the accoucheur in the operation of the crotchet, the uterus was bruised against the linea innominata: hence the appearance, peculiar to this case, of blackness and gangrenous sloughs on the edge of the rent in the uterus.† In this case also, the immediate cause of the rupture was the contraction of the uterus, in the attempt to force down and deliver the infant, the violence of which action falling upon the weakened part of the uterus, near the orifice, tore it: the head of the child being locked in the pelvis, was undoubtedly the cause why the whole child was not thrown into the cavity of the abdomen.

I have examined the uterus cut in the operation of Cæsarian section. On opening the belly, I saw the uterus lying contracted; but the wound of it was gaping, the lips everted, and it now appeared as if the uterus had been cut from the fundus to the neck. This

* I shall not presume to deny, that the vagina and not the uterus has been sometimes ruptured: yet from the general resemblance in the circumstances of the cases of ruptured uterus and the appearance of the torn parts, I think the rupture takes place in the uterus, near the orifice. If the orifice of the uterus be relaxed and open, the vagina will not remain rigid, the child's head will descend: if there be no resistance to the contraction of the uterus, the violence of the action cannot be such as to tear the parts. The child and placenta being found in the cavity of the belly, declares the rupture to take place before the full descent of the head into the pelvis, that is, before the final dilatation of the orifice of the uterus.

† The linea innominata was in this case very sharp; the skeleton is in my Collection.

singular appearance and deception I attributed to the contraction of the body of the uterus, while the edges of the incision remained paralysed and uncontracted.* The thickness of the womb was increased to four times the diameter it presented during the operation: but what most deserved attention was the appearance of the large vessels, now with open mouths, which during the operation were not apparent. From the mouths of those vessels the streaming blood had been coagulated, and now formed strings, reaching from the mouths of the vessels to the great cakes of coagulated blood which lay on each side of the abdominal cavity. Besides the coagulated blood which lay in the cavity of the abdomen, a large clot was in the cavity of the uterus.†

From this we see, that when the substance of the uterus is cut, either the muscular fibres do not fully contract, or in their contraction in consequence of being cut across, they do not constringe the blood-vessels.

The muscular structure of the womb becomes a subject of very great interest in connection with that of *flooding*; it has been proved by the sections of the uterus, made in different states of its contraction, that the order of the muscular fibres is such as to close the vessels; that where nature has provided for the attachment of the placenta, there the broken vessels are guarded by the provision of the surrounding muscular texture; but we know also, that during this contraction of the superior part of the womb, the lower part dilates and relaxes. Now if the contraction of the womb be essential to the safety of the mother, what will be the effect of the attachment of the placenta to a part of the womb which must relax during the labour? Every one knows the peculiar danger of the case of *placenta prævia*, that each labour pain, as it returns, increases the

* Precisely the same appearance presented in the case communicated by Dr. Hunter, Med. Obs. and Enq. v. 4. Mr. Thomson's incision was six inches in length of the gravid uterus: on dissection the uterus was found contracted to the size of a common melon, and the wound appeared nearly the whole length of its body.

† This corresponds with the dissection in the case communicated by Dr. Hunter.

violence of the flooding, instead of checking it. In common cases, breaking the membranes and accelerating the labour, checks the flooding, and secures the safety of the patient; but when the placenta is attached to the orifice of the uterus, the reverse of this takes place.

From attention to the muscular structure of the uterus I have been led to conclude, that in common cases of flooding, during labour, the hæmorrhage is not accidental, in any other meaning of the term, than as it proceeds from the place of the uterus to which the placenta is accidentally attached: that the placenta cannot be partially separated if it be attached in a regular circle to the fundus of the uterus; and that flooding on the commencement and during the progress of labour, is owing to an irregularity in the shape and attachment of the placenta.

When the placenta is attached in a regular circle to the fundus uteri, it cannot be partially separated, and cannot be separated bodily, until the uterus is permitted to have a great degree of contraction by the delivery of the child; the circular muscles of the fundus being agents in a double capacity, that is, both expelling the child, and in constringing the uterine vessels; by the time that the child is expelled, the vessels of the fundus are greatly diminished in diameter. Further, the place and strength of these muscles being perfectly regular and uniform, their action must have the effect of equally drawing the surface of the uterus, which is in correspondence with the margin of the placenta, towards the centre of the fundus, and consequently of separating the surface of the uterus from the placenta; but no one part of it will be separated until the general restriction is nearly completed. This will not be the case when the margin of the placenta extends irregularly, or when the placenta is attached to the side of the uterus. After the delivery of the child in cases of flooding, it is not uncommon to find a portion of the placenta low down in the uterus, and separated, while the greater portion remains attached to the fundus. In examining the inner surface of the uterus by dissection, I have seen the part

corresponding with the placenta irregular in its form, and extending towards the side and neck of the uterus. In such circumstances of the attachment of the placenta, the retraction of the lower part of the womb being to a greater extent than the fundus, will account for the too early separation of that margin of the placenta which stretches towards the orifice, and also for the hæmorrhage, which is a consequence of this partial separation; but in progress of the labour, and after the discharge of the waters, the more powerful efforts of the uterus draw the muscular fibres more closely around the blood-vessels, and then the flooding ceases.

The flooding which attends the torpor of the uterus in any circumstances, when the connection with the placenta is broken, will be very easily accounted for on recurring to the details of the anatomy given already.

OF THE MAMMÆ.

In man and in children of both sexes, there is no mark of the breast, but the little cutaneous papilla, or nipple. These tubercles are, however, surrounded by a zone or disk, of a brownish red colour, the areola.

At puberty, as we have said, the breast of the female becomes protuberant, and those parts which were in miniature, and without action, quickly grow into a firm glandular mass. The shape, rotundity, and firmness of the gland depends much upon the adipose membrane surrounding and intersecting the glandular body.

The glandular part itself is divided into little masses, which again consist of small granules. These several subdivisions of the glands are closely surrounded by membranes.

The lactiferous ducts are gathered together from these lesser granules, and unite into twelve or fifteen in number of a very considerable size, as they converge towards the root of the nipple. When milk is secreted, the glands are large, a remarkable distention of the ducts also takes place, for they are then become tortuous and varicose, and serve as reservoirs of the milk. Where they pass through the nipple, however, they are again contracted,

and open by small pores upon its surface. The nipple is of a spongy and elastic nature, and suffers a distention or erection. When the nipple is contracted, the lactiferous ducts must be compressed, and perhaps coiled together, so that the milk cannot flow, or flows with difficulty; but by the sucking of the child, the nipple is distended, and the ducts elongated, so that the milk flows. There open upon the areola several superficial or cutaneous glands, which pour out a discharge to defend it and the nipple from excoriation.

Of the arteries, veins, or lymphatics of the mammæ, we need not treat here.

We have many occasions to observe the consent and sympathy which exist betwixt the womb and the breasts. On the first period of the menses, the breasts are much distended. In many women, at each return of the discharge, a degree of swelling and shooting pain is felt in them, and the enlargement and shooting pain in the breast, with the darker colour of the areola, is marked as the most prominent sign of pregnancy; with the ceasing of menstruation, which is the cessation of the usual excitement and action of the womb, the breasts contract and are absorbed. Any unusual stimulus or irritation in the womb, as polypus, or cancers, or even prolapsus and excoriation, will affect the breasts, causing them to enlarge and become painful.

When the function of the parts ceases, they seem to feel the want of the usual excitement to correct action, and are apt to fall into disease; so it is at least with the womb and mammæ, for at that period of life, when the system is no longer able to support and give nourishment to a child, and these parts subside from their usual action, they often become scirrhous or cancerous, and terminate existence by a tedious, painful, and loathsome disease.

THE END.

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Fig. 1

Fig. 2